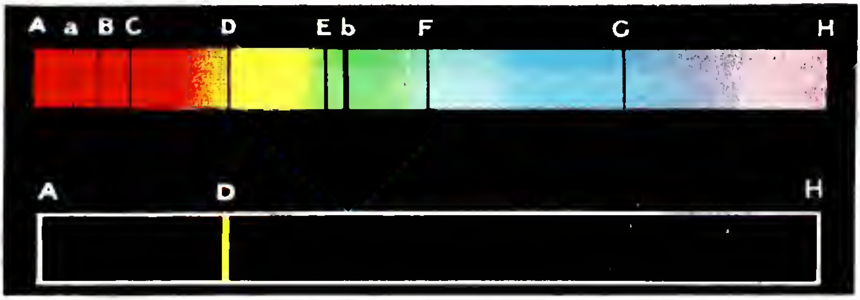
LIFE OF MATTER

Date Due

THE LIFE OF MATTER

The colours of the rainbow, from red to violet.



The D line of Soda. When the metal sodium is burned in a flame a bar of yellow light appears in the colour-spread thrown by a crystal. But lithium burns red, and thallium burns green.

THE LIFE OF MATTER

AN INQUIRY AND ADVENTURE

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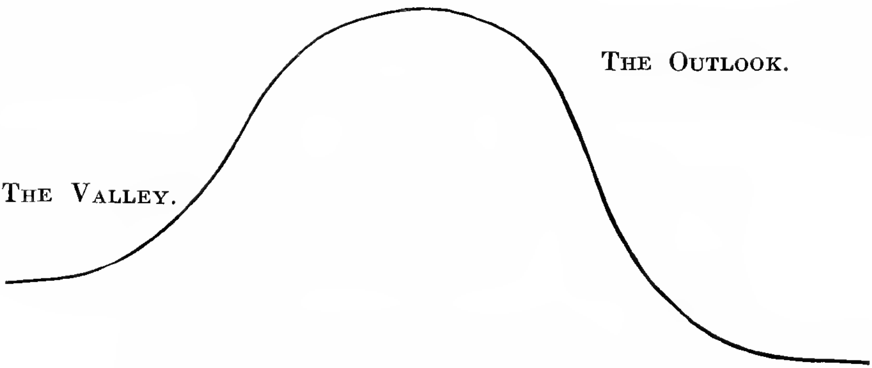
PREFACE



TO THE MANY HELPERS.

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GENERAL SUMMARY OF "THE LIFE OF MATTER"

THE work is in three sections :—

1. The chemical elements and their changes.

Experiments on elements, illustrating actions of mechanical strain, heat, light, physico-chemical, electro-magnetic, and other actions.

Evolution of the stars.

Relation between element and tissue.

Charles Darwin and natural selection.

Force or energy—its conservation and dissipation.

Philosophic discussion on relation of man to nature.

2. The inquiry proper considers the methods of search, states certain definitions, observes certain facts of everyday experience, and, after giving a simple introduction into the methods of numbers and statistics, proceeds to the actual proof that man is an active being.

3. This conclusion being established, we then enter upon some applications of science to society in such matters as the cancer problem, the subject of infant mortality and health, the outlines of elementary education ; concluding with a simple experimental proof of the fact that those substances formerly thought dead are, in reality, alive. No attempt is made to elaborate these subjects in detail, but to concentrate attention upon the essential point in each.

The Prussian idea of Force is shown to be in contrast with the more British idea of Activity ; which is destined to remain and finally oust the more rigid and intellectual conception of the Continent.

The work purports to supply—in illustrative, though sketchy, form—a reliable guide and insight into observational method and experiments. It attempts to interpret the general body and bearings of the more important principles of knowledge to the average young man or woman entering college or naturally keen, and to provide a stimulus to any ordinary individual desirous of understanding the widespread applications of modern science to the necessities of real life. It endeavours both to appreciate past workers in their results, and also to suggest fresh fields for inquiry and discovery.

Part I

THE VALLEY

SUMMARY

Death? Life?

Two valleys . . . A lofty ridge between, a mountain hardly surpassable.

One old, pleasant, fair, and narrow.

One ample, but shrouded in mist.

Shall we face the mountain-side, risking false summit upon false summit—for one fresh breath, for one glimpse, of that ampler valley.

Is it worth it?

Ay, together; hand to hand; humble as little children as we grope a way up the banisters to bed, stumbling, falling, crying ever in the darkness after the Light.

THE VALLEY

" Turn," bade the Accompanier to the man, " and cast your eye upon the valley you are about to forsake. What see ye, say ? "

He looked : behold, there was nothing but a murk and fog. Aslant it rolled great banks of clouds, seaward-driven by the wind, hiding downwards the view and what was therein contained. Six times the vapours rolled across the vision. At thc seventh he called sudden, " I see darkness."

" Look again," said the Guide.

Once more the clouds swept over. At length he said : " I feel the air strike upon my cheek. The darkness parts. I see a form, not erect, crawling on mud and sand. It disappears."

" What next ? " quoth the Guide.

" I seem to see—yes, a figure, hunting. Or is it a shepherd tending his sheep ? I cannot clearly discern, for the vision is afar off. It vanishes. Anew I see a man sowing seed in the ground near by a wooden hut, in front of which smoulders a fire of logs. The bank lifts again. The hut has multiplied. I note a village. The mists collect."

" Can you descry nothing more ? "

" Yes ; there looms up a city, set upon crags, with lofty and stern pillars of stone, and a prison. A few men come out bearing the body of a man from within—an elderly man, of whitened hair. They eddy and wreathe away."

" Who next ? "

" A man clinging upon a cross of wood. Near beside there leans a soldier upon a spear.

" I see the ocean and a sail. It approaches. Upon the poop, alone, there stands a man, beckoning westward. He disappears on into the sunshine. Again, there shows one dressed in the garb of a monk. He takes a book from the hand of a printer, deciphers and unclasps it to the view of the many. And now pass many figures, crowded masses, flitting, lingering. Stay, there is one—a

lad. He sits beside a kitchen fire and gazes into it. Upon the fire is a kettle. Steam streams from out the spout. The lid of it pants up and down. He watches it; he watches it intently. This picture is so clear!"

"Look in! look in!"

"The valley obscures with smoke, and there arises a noise of many wheels and looms and engines, the sparkling of light. Yet does the darkness deepen. And out therefrom the roar of forges and the clanging of hammers. And—stop! harken! I hear the sound of men and women crying silently."

He turns to the Leader. "Why so? Tell me why so?" he asks. "Tell!"

Throughout the valley are two parties, East and West. The leaders of the East have said: "Thou shalt not kill." The leaders of the West have said: "Thou shalt kill."

Let us therefore lay hold on the fringes of the ample folds of Western knowledge.

Western men have imaged two things. The earth with its contained bodies—iron, copper, silver, gold, coal, and salt. The roll of the sea. The fleecing and gathering clouds. The twilight of the stars. These are more or less solid. They appear dead to Western man, for by the aid of the chemist he resolves them into various "elements." One thing!

Then he sees the plants and the animals on the surface of the earth, from the blade of grass to man. These he terms "tissues," and regards them as alive. Another thing!

Let us briefly consider Western man, both concerning element and concerning tissue.

SURVEY: SECTION I.

ELEMENTAL MATTER.

The International Committee of Chemists consists at present of three representatives: one from the United States, one from Britain, and one from France. They declared the names, abbreviated signs, and estimated relative weights of the elements known in 1917 to be:—

Substance.		Symbol.	Substance.		Symbol.
Aluminium	27·1	Al	Lead	207·2	Pb
Antimony	120·2	Sb	Lithium	6·94	Li
Argon	39·88	A	Lutecium	175·00	Lu
Arsenic	74·96	As	Magnesium	24·32	Mg
Barium	137·37	Ba	Manganese	54·93	Mn
Beryllium	9·1	Be	Mercury	200·6	Hg
Bismuth	208·0	Bi	Molybdenum	96·0	Mo
Boron	11·0	B	Neodymium	144·3	Nd
Bromine	79·92	Br	Neon	20·2	Ne
Cadmium	112·4	Cd	Nickel	58·68	Ni
Cæsium	132·81	Cs	Niobium	93·1	Nb
Calcium	40·07	Ca	Niton	222·0	Nt
Carbon	12·005	C	Nitrogen	14·01	N
Cerium	140·25	Ce	Osmium	190·9	Os
Chlorine	35·46	Cl	Oxygen	16·00	O
Chromium	52·0	Cr	Palladium	106·7	Pd
Cobalt	58·97	Co	Phosphorus	31·04	P
Copper	63·57	Cu	Platinum	195·2	Pt
Dysprosium	162·5	Dy	Potassium	39·10	K
Erbium	167·7	Er	Praseodymium	140·9	Pr
Europium	152·0	Eu	Radium	226·0	Ra
Fluorine	19·0	F	Rhodium	102·9	Rh
Gadolinium	157·3	Gd	Rubidium	85·45	Rb
Gallium	69·9	Ga	Ruthenium	101·7	Ru
Germanium	72·5	Ge	Samarium	150·4	Sa
Gold	197·2	Au	Scandium	44·1	Sc
Helium	4·0	He	Selenium	79·2	Se
Holmium	163·5	Ho	Silicon	28·3	Si
Hydrogen	1·008	H	Silver	107·88	Ag
Indium	114·8	In	Sodium	23·00	Na
Iodine	126·92	I	Strontium	87·63	Sr
Iridium	193·1	Ir	Sulphur	32·06	S
Iron	55·84	Fe	Tantalum	181·5	Ta
Krypton	82·92	Kr	Tellurium	127·5	Te
Lanthanum	139·0	La	Terbium	159·2	Tb

Substance.		Symbol.	Substance.		Symbol.
Thallium . .	204·0	Tl	Vanadium . .	51·0	V
Thorium . .	232·4	Th	Xenon . . .	130·2	X
Thulium . .	168·5	Tm	Ytterbium . .	173·5	Yb
Tin . . .	118·7	Sn	Yttrium . .	88·7	Y
Titanium . .	48·1	Ti	Zinc . . .	65·37	Zn
Tungsten . .	184·0	W	Zirconium . .	90·6	Zr
Uranium . .	238·2	U			

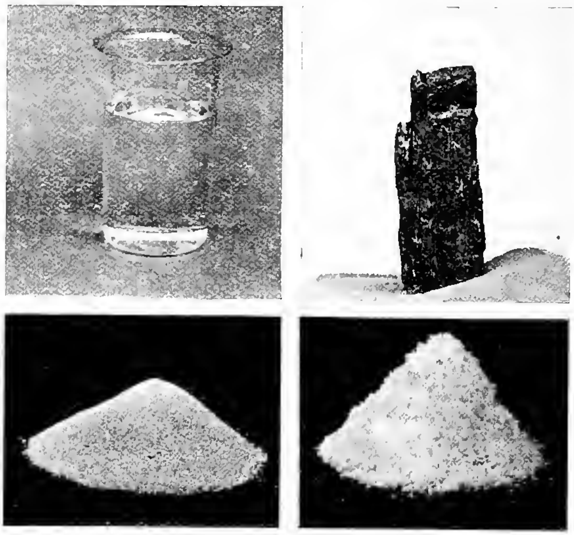


FIG. 1.—Water, coal, sand, and salt.

These elements, the labour of the chemists, are eighty-three in number. Each has its own character. The gas hydrogen is the lightest, the white metal uranium the heaviest. The blade of our pocket-knife is hard: it is of "iron." The metal cooking-pot, if made of shiny aluminium, is light. The glass of our tumblers and windows is brittle and translucent: it is of "silicon." And the liquid in our garden thermometer is bright and motile: it is of "mercury," the one metal liquid at an ordinary room temperature.

The substances most widely distributed in nature contain a very small number of elements. Water is formed by the gases hydro-

gen and oxygen. The commonest elements, according to Dmitry Mendeléeff, the Russian chemist, are :—

Hydrogen.—In water, and animal and vegetable organisms.
Carbon.—In organisms, coal, limestones.
Nitrogen.—In air and in organisms.
Oxygen.—In air, water, earth : forming the greater part of the mass of the earth.
Sodium.—In common salt and in many minerals.
Aluminium.—In minerals and clay.
Silicon.—In sand, minerals, and clay.
Phosphorus.—In bones, ashes of plants, and soil.
Sulphur.—In pyrites, gypsum, and in sea-water.
Chlorine.—In common salt, and in the salts of sea-water.
Potassium.—In minerals, ashes of plants, and in nitre.
Calcium.—In limestone, gypsum, and in organisms.
Iron.—In the earth, iron ores, and in organisms.

At first sight the eighty-three elements seem a perfect jumble-sale of numbers. So chemists like J. A. R. Newlands (1838–1898) of England and Italy, Lecoq de Boisbaudran of France, and Lothar Meyer of Germany tried to establish some harmony out of the seeming chaos ; Newlands comparing the elements then known to the notes of a piano-scale, every eight notes and every eight elements in weight being repeated as in an octave, the one in tone, the other in quality. For instance, it was soon noticed that the elements lithia, 7, soda (or natrium, after the Greek), 23, potash, 39, rubidium, 85, cæsium, 133, and thallium, 204, though different in weight, are not unlike in character, being white metals with a taste akin to baking soda, and combining with the acids to form crystals of a cube shape.

But it was reserved for Dmitry Mendeléeff of Russia to arrange the substances into such a sequence as to predict the existence of elements not yet discovered. Thus, picking out twelve elements —barium, bromine, calcium, cæsium, chlorine, fluorine, iodine, magnesium, potassium, rubidium, sodium, and strontium—and setting them down upon paper in order of weight and in vertical groups of three, we get :—

F = 19.	Cl = 35.	Br = 80.	I = 123.
Na = 23.	K = 39.	Rb = 85.	Cs = 133.
Mg = 24.	Ca = 40.	Sr = 88.	Ba = 137.
D = 16.	D = 46.	D = 48.	

We note first that the elements of the first group are separated from the elements of the second group roughly by 16; those of the second from that of the third roughly by 46; those of the

Fig. 2.—Dmitry Mendeléeff, Russian chemist.

third from that of the fourth roughly by 48. And associated with this number repetition we find a repetition in the qualities of the substances :—

1. The first horizontal row of substances show a colour and density sequence :—

Fluorine	Green light gas.
Chlorine	Yellow gas.
Bromine	Brown liquid.
Iodine	Purple solid.

2. The second horizontal row are the white soda metals.

3. The third horizontal row are known as the alkaline earths, such as magnesia and chalk and lime.

And in 1869 Mendelćeff arranged all the elements then known, and so found an orderly or periodic relation between the elements in weight and form and quality ; and at that time he was able to predict that elements, other than the ones then known, would be discovered to fill the gaps in the order of the elements—a prophecy subsequently verified by the finding of germanium in Germany by C. Winkler, gallium in France by Lecoq de Boisbaudran, and scandium by Nillson in Sweden.

The union of the elements yields us various substances. The common salt of our tables arises from the union of a soft white substance, soda, and a greenish-yellow gas of pungent and acid smell, called chlorine, frequently used in battle for the poisoning of human beings.

The chemical name for hydrochloric acid is HCl.

Helium and Radium.—The old alchemists, sensible of some deeper uniformity of the elements, tried to change and transmute lead into gold. These early efforts broke down, but more recently, in the change of the body radium into the body helium, they have been proven prophets. Thus, to sketch this historic drama of helium and radium, the first the discovery of Westerners, the second of Continentals :—

Helium.

In 1868 Janssen and Lockyer viewing the light around the sun found it remarkable by a bright yellow line. And because there was no line like it in any of the known bodies of earth, Lockyer gave it the Greek name "helium." It was afterwards seen in the stars. Thirty years elapsed before it was found upon the earth. The American, Hillebrande, saw that the mineral clevite, a mineral rich in the element uranium, when heated or dissolved, gave off much gas ; he thought this gas was nitrogen.

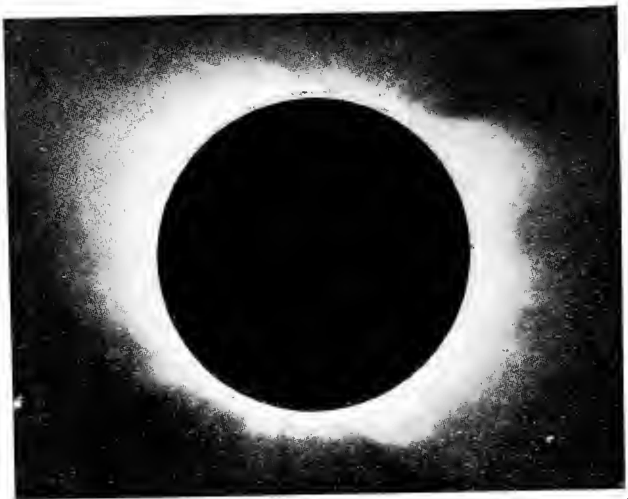
William Ramsay procured some

Radium.

In 1867 Niepce de Saint Victor observed that salts of uranium enclosed in a tin case left impressions on a photographic plate, even in the dark.

In 1895 Roentgen in experimenting with a Crookes' tube discovered the X-rays.

Becquerel, in experimenting with the salts of uranium—which were phosphorescent—observed that crystals of the double sulphate of uranium and potash left an impression on a photographic plate, even in the dark—an action like that of X-rays travelling from substance to plate.



(*After George Ellery Hale, in the University of Chicago Press.*)

FIG. 3.—The solar crown, photographed by the Yerkes Eclipse Expedition, May 28, 1900.

(*After George Ellery Hale, in the University of Chicago Press.*)

FIG. 4.—The sun's chromosphere and prominences.

clevite, and examined it in the belief that the gas from it might be argon (the gas already found by Rayleigh and Ramsay); but it did not seem the same.

Lockyer then examined it, and found in it the light yellow line of the element helium.

Then Schmidt and Madame Curie found how the body thorium gives out a similar action; the same for potash (Campbell).

Curie examined many substances for this action, and found it very strong in pitch-blend, *e.g.* in the mineral chalcolite.

She prepared artificial chalcolite, and found the natural mineral chalcolite was about five times as active as the artificial product. There was something, therefore, within the natural mineral. She isolated this substance —"radium."

Ernest Rutherford and Frederick Soddy then found that radium yields the bright yellow line of helium. These two elements, formerly thought different, have therefore coalesced into one, just as two pictures blend in the stereoscope. In the words of Rutherford, we are witnessing in the radioactive bodies a veritable transformation of matter.

Other substances change, though not so far as from element into element; just as a woman can doff one dress and don another. Instance: tin, phosphorus, and carbon.

Tin.—Tin has two forms—common white and grey. A remarkable incident has been recorded where a quantity of military buttons, consisting mainly of tin, were delivered by the manufacturer and placed in store; on the next official inspection the buttons had become a shapeless mass of grey powder.

The tin had changed in weight and shape and electric condition. The famous physico-chemist, J. H. van't Hoff, described the change as follows:—

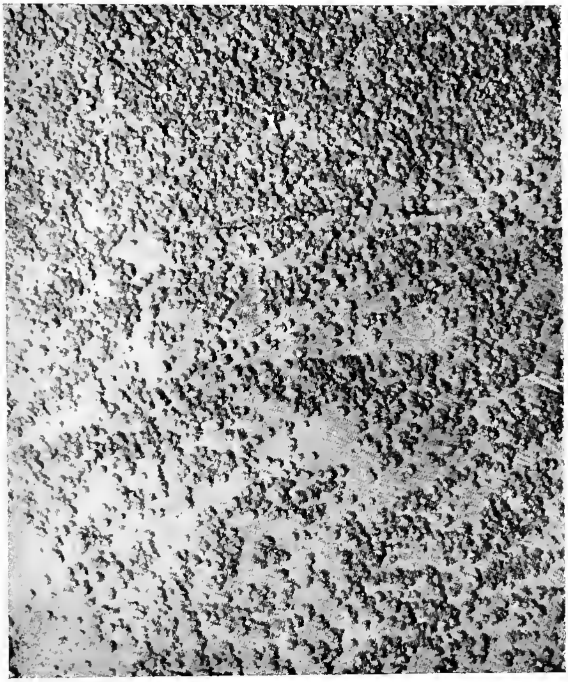
"The remarkable fact in the behaviour of tin to which I ask your attention was discovered long ago. Careful historical investigation has demonstrated that even Aristotle was acquainted with the fact whose explanation has so recently been brought to light. The fact referred to is, common tin is capable of undergoing a profound change which amounts to a complete disguise. The product of this change, for reasons which we shall learn later, cannot be exhibited to you, and I must therefore content myself by showing a photograph of a piece of tin which is undergoing this transformation. The impression which examination of this piece of tin makes is that of an object which has been overtaken by some disease. As a matter of fact, indeed, the phenomenon has this in

(*The Illustrated London News.*)

FIG. 5.—Tin coin, obverse and reverse, struck with the tin-pest.

FIG. 6.—J. H. van't Hoff, Dutch chemist.

common with disease, that it is contagious. When the phenomenon exhibits itself, as it sometimes does, in the pipes of church organs, it is consequently a good plan to remove the objects which have become infected. The disintegration into a grey powder, which marks the progress of attack, proceeds gradually until, especially in the case of thin bodies like organ pipes, the object has been



(After J. H. van't Hoff, in the University of Chicago Press.)

FIG. 7.—Tin disease.

completely destroyed. We must not delay to add that, in spite of appearances, the change is not due to the influence of the atmosphere or its moisture. On the contrary, the tin undergoes the change all by itself, and the grey product has only to be heated in order that without change of weight it may be re-obtained in the original metallic form. It is precisely on account of the influence of heat on the change that at the temperature which we are at present experiencing I am unable to show this so-called grey tin.

"We owe particularly to Schaum and Cohen our knowledge of the conditions which influence this extraordinary change. The conclusion is that the whole phenomenon is related to a definite temperature, namely 20° C. Below this temperature the formation of grey tin can occur, while only above this temperature is the formation of the common variety possible. The temperature limit 20°, commonly known as the transition period, separates two ranges of temperature in which the grey and the white tin respectively are stable."

Phosphorus.—This is a body found in the earth, in plants, and in animals. There is red phosphorus and white or "metallic" phosphorus, phosphorus Jekyll and phosphorus Hyde! White phosphorus melts, is greedy of the gas oxygen, and is poisonous, being unlike red phosphorus in these three points. But with a trace of iodine white phosphorus transforms into red phosphorus.

Carbon.—This can assume three forms—charcoal, graphite, and diamond. On combustion they are said to yield the same weight of carbon dioxide gas. Charcoal is a disinfectant, diamond is not; graphite is black, soft, and greasy, whereas diamond is colourless, transparent, and the hardest of all known minerals. Yet the three are believed to be identical in composition; and diamond can change into graphite.

Water.—Even water assumes other states, at least three in number —solid, liquid, and vapour: ice, water, and steam.

Explosion, as in gunpowder and the dynamites, is but such another transformation of substance, though a rapid one. Christian Frederick Schönbein (1799–1868) announced his discovery of guncotton on 27th May 1846 at a meeting of the Society of Scientific Research at Bâle:—

"I made a mixture of 1 volume of nitric acid (1·5) and 2 volumes of sulphuric acid (1·85) and cooled the mixture to 0° C. I then added some finely-powdered sugar so as to form a paste. I stirred the whole, and at the end of a few minutes the saccharine substance formed itself into a viscous mass, entirely separated from the acid liquid, without any disengagement of gas. The pasty mass was washed with boiling water until the latter no longer showed any acid reaction; after which I deprived it as much as possible, at a low temperature, of the water which it still retained. The substance now possessed the following properties: Exposed to a low temperature it is hard and brittle; at a moderate temperature it may be moulded like jalap resin, which gives it a beautiful silky lustre. It is semi-fluid at 100° C.; at high temperature it gives off red vapour.

Heated still more, it rapidly deflagrates with violence, without leaving any perceptible residue ; with friction it is electrical.

"All this occurred in December 1845 and the first months of 1846. In March I sent specimens of my new compounds to some of my friends, especially Faraday, Herschel, and Grove. I must add that hardly was it discovered when I employed it in shooting experiments, the success of which encouraged me to continue them. Accepting the obliging invitation which I received, I went to Würtemberg in the middle of April, and made experiments with gun-cotton, both in the arsenal at Ludwigsburg, in the presence of artillery officers, and at Stuttgart, before the King himself. In the course of May, June, and July, with the kind co-operation of Commandant de Michel, M. Burkhardt, captain of artillery, and other officers, I subsequently made in Bâle numerous experiments with arms of small calibre, such as pistols, carbines, etc., and afterwards with mortars and cannon, experiments at which Baron de Krudener, the Russian Ambassador, was several times present. I may be allowed to mention that I was the person who fired the first cannon loaded with gun-cotton and shot, on 28th July 1846, after we had previously ascertained by experiment with mortars that the substance in question was capable of being used with pieces of large calibre. About the same time, and independently, I employed gun-cotton to blast some rocks at Istein, in the Grand Duchy of Baden, and to blow up some old walls at Bâle, and in both cases I had opportunities of convincing myself, in the most satisfactory manner, of the superiority of this new explosive over gunpowder. In July I also made the first capsules, and employed them with success for muskets in the presence of the above-named officers. Experiments of this kind, which took place frequently, and in the presence of a great number of persons, could not long remain unknown, and the public journals soon gave, without participation on my part, descriptions more or less accurate of the results which I obtained. This circumstance, joined to the short notice which I inserted in the May number of *Poggendorff's Annalen*, could not fail to attract the attention of German chemists. In the middle of August I received from Böttger, Professor at Frankfort, the news that he had succeeded in preparing gun-cotton and other substances.

(Moving photo, by T. J. Walls, Edinburgh)

FIG. 8.—Explosion of gun - cotton under sea, near Inchkeith, Firth of Forth.

Our two names became associated in the discovery of the substance in question. To Böttger, gun-cotton must have been particularly interesting, as he had previously discovered an organic acid which deflagrated readily. In August I went to England, where, assisted by the able engineer Richard Taylor of Falmouth, I made numerous experiments, in the mines of Cornwall, which were entirely successful in the opinion of all competent witnesses. Experiments on the action of gun-cotton were also made in several parts of England, under my directions, both with small firearms and pieces of artillery, and the results obtained were very satisfactory."

The famous explosive T.N.T. (tri-nitro-toluol) is a further scientific production, which transforms rapidly.

Alloys.—In these and other changes the state of a body is like the equipoise of a bird hovering on the wing, a moving equipoise. Take a penny, a mixture of copper 95 parts, tin 4 parts, and zinc 1 part: it is an alloy. The inter-blending in an alloy is often of the most intimate kind, and small differences may lead to marked changes in appearance and character of the elements concerned. Thus, in the case of our ordinary incandescent mantles: if soaked in pure oxide of thorium they become only slightly luminous on heating, but if to the oxide of thorium 1 per cent. of oxide of cerium be added, the mantle becomes brilliantly luminous on heating, and gives us the light we know so well. Again, the early pioneers in Atlantic cables soon discovered that pure copper was indispensable to their purpose. The copper cable of to-day, through purifications of the metal, carries twice the number of messages borne in the year 1858. Roberts-Austen, who speaks with authority, maintains that 0·1 per cent. of bismuth would prove fatal to the commercial success of the cable. An alloy of copper, pure but for 3 per cent. of aluminium, has a resistance to electrical conduction about $5\frac{1}{2}$ times that of copper: a little mixture making or marring.

Moreover, a mixture of elements may have properties different from each of the elements taken singly. Compress a finely-divided mixture of bismuth 15 parts, lead 8 parts, tin 4 parts, and cadmium 3 parts, and an alloy is formed which melts at 100° C., a figure much below the melting-point of any of these four metals taken singly (Spring).

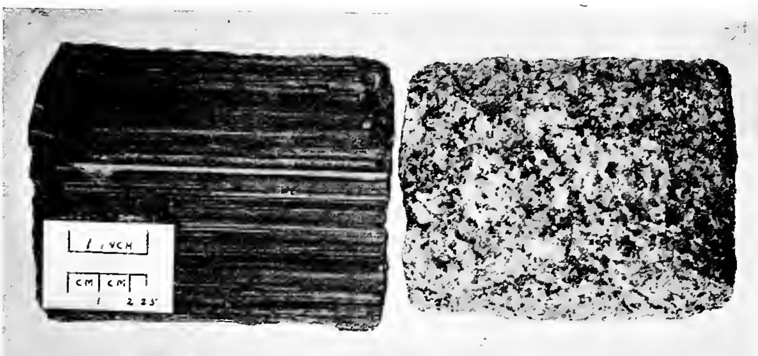
The elements copper, manganese, and aluminium are not magnetic like iron, yet an alloy of these three elements *is* magnetic.

Matter in Action.

Let us now view some more changes of matter in action :—

A. *Mechanical.*

Water is a mysterious body : solid but sensitive ; solid when you strike it when diving, sensitive on mechanical agitation. If its temperature be gradually lowered and the water kept quite still, it can reach many degrees below its usual freezing-point (about 0° C.) without assuming the ice state. If then the sides of the containing vessel be tapped or the water slightly troubled by a sound or by a particle thrown on its surface, it instantly begins to transform into



(*By the courtesy of J. W. Gregory, University of Glasgow.*)

Fig. 9.—Samples of gneiss and granite. The scale lies on the gneiss.

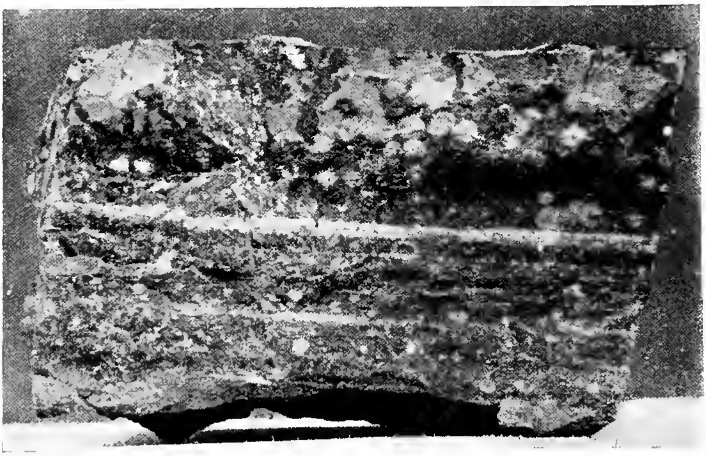
ice. Water also changes readily on pressure ; for in the tracks of a cartwheel in the snow the snow melts on pressure, and then re-freezes hard. Or rest a block of ice upon a wire, and the wire cuts its way through the ice, the water (ice) changing into water (water), the molten water then freezing up again, leaving the block still solid.

Even bodies harder than water can flow.

Roberts-Austen kept a cylinder of lead pressed for a year against a cylinder of gold by screws, and the gold diffused right into the lead, for, in cutting and testing sections of the lead cylinder, gold was found right through it. And Tresca placed metal discs of lead, copper, silver, and iron in a cavity drilled in a block of steel and exposed them to great pressure, until the metals flowed through the narrow opening in the bottom of the cavity in a continuous solid stream.

Even pure Carrara marble has been induced to flow.

Such changes appear also in the earth. The rocks alter by the heavy pressure, crushing and shearing they endure, together with the influence of heat and moisture. Clays and shales transform into roofing slates, sandstone into quartzite, limestone into marble, granite into gneiss, and vegetable matter into lignite and coal. One of our ablest geologists, Archibald Geikie (born 1835), denies that these changes are due to the introduction of external materials. Charles Lyell (1797–1875) called them the "metamorphism" of rocks.



(By T. C. Day, Edinburgh.)

Fig. 10.—Transformation within a rock, from a calcareous shale into silicate of lime or wollastonite (the whiter patches).

Good instances are seen among the Alps, in the Chilian conglomerate, in the Pyrenees, in the Vosges, in the vitrified sandstones of the Thuringian Forest of Central Germany, in the carboniferous limestones of Central England, in the rocks of Donegal, in the highlands and southern uplands of Scotland. And Judd's description of a beautiful instance of rock-change in the district of Schemnitz, in Hungary, may be quoted :—

"We have here the ruins of a great volcano. Paroxysmal eruptions have blown away a large portion of the cone, and denudation has further eaten down into the crateral hollow thus produced to such an extent that sections are laid bare through the very bowels of the volcano. In this way the great Plutonic masses, which are the hardened contents of the old volcanic crater, have become exposed to

view. These intrusive bodies have wrought local metamorphism among the bedded rocks through which they were forced, and have converted them into schists, quartzite, crystalline, limestone, gneiss, and aplite. There can be no question about these crystalline rocks being true products of metamorphism, for they can be traced, passing by the most insensible gradations into the unaltered bedded rocks which adjoin them."

Transformations of rocks have also been effected by experiment in geological laboratories.

We cannot even strike a metal but it changes.

George Thomas Beilby has experimented on metals, and writes: "By a single blow with a hammer a cylinder of ductile metal is instantly transformed, so that its mechanical properties are as completely changed as if the metal had been converted into a new compound by alloying. This transformation certainly does not depend on the presence of foreign substances or of mixed constituents, for the property of hardening is not in the least diminished by the most careful purification of the metal."

Fig. 11.—Vitrified sandstones of the Thuringian Forest, Central Germany.

Again, by drawing, the tenacity of the metals—gold, silver, and copper—is increased.

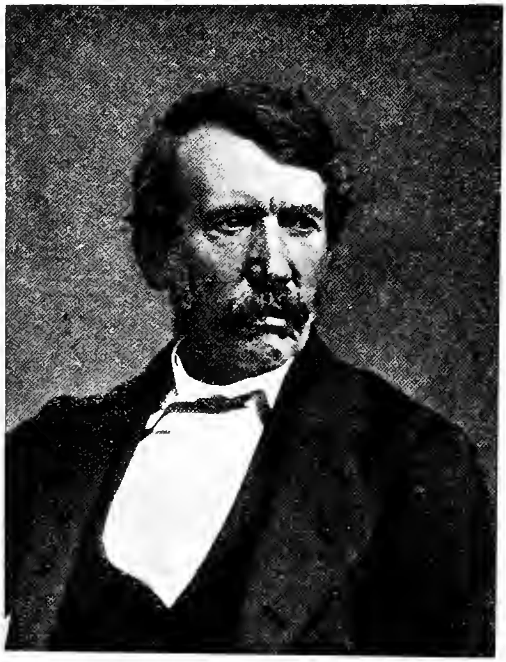
And again, a wire which has been hardened by simple stretching is different from one which has been hardened by hammering or by wire-drawing.

B. *Heat Action: Cold Action.*

Archibald Geikie relates that: "In dry tropical climates, when the days are intensely hot and the nights extremely cold, the rapid nocturnal contraction produces a strain so great as to rival frost in its influence upon the surface of exposed rock, disintegrating them into sand, or causing them to crack or peel off in sections or irregular

pieces." For instance, David Livingstone found in Africa (12° S. lat., 34° E. long.) that surfaces of rock which during the day were heated up to 137° Fahrenheit, cooled so rapidly by radiation at night that, unable to sustain the strain of contraction, they split and threw off sharp angular fragments from a few ounces to 100 and 200 lbs. in weight.

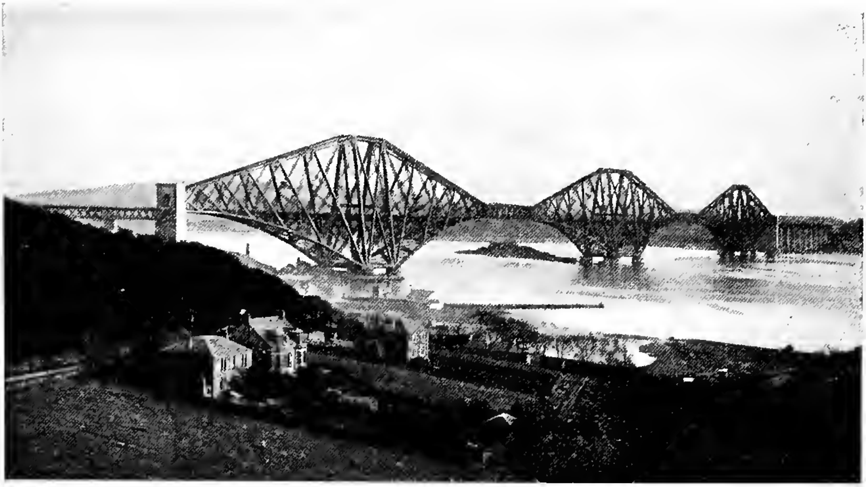
But one need not seek the deserts of Africa for instances of action



(*After the original photo by Thomas Annan*)

FIG. 12.—David Livingstone, explorer.

following heating. You may be seated quietly in your chair when you hear a sudden "ping." You step to the table at the window and notice a crack in one of the flower glasses on which the sunlight is beating. An event of interest! Glass an explosive! Then look at the expansion of iron. You stand at your suburban station waiting for your train. The rails, you see, are laid in sections, with little interspaces, or else they would jam up. The Forth Bridge moves out and in, summer and winter, over a distance of 24 inches, and its bolt holes have to be oblong instead of round. Similarly in

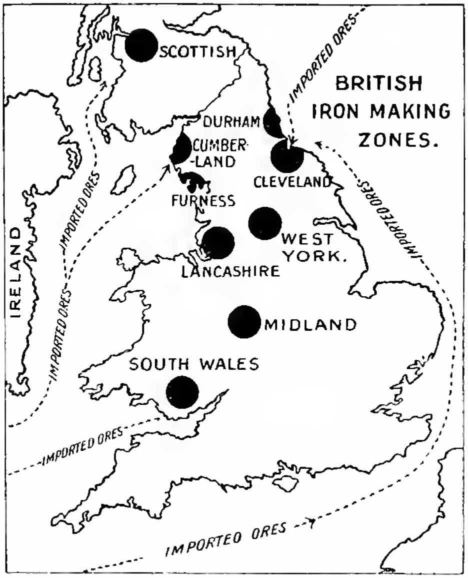


(*Photo by Ritchie & Sons, Edinburgh.*)

FIG. 13.—The cantilevers and spans over the estuary of the Forth : seen from the north-west.

(*The Illustrated London News.*)

FIG. 14.—The Eiffel Tower, Paris.



(*Redrawn after Walter MacFarlane.*)

FIG. 15.—The British iron-making zones.

FIG. 16.—A puddler at work. The water-bath lies to his left elbow.

that great vertical structure, the Eiffel Tower of Paris; Guillaume ran a relatively inextensible nickel-steel wire from the ground up to the first stage, charted its movements, and found the tower responds immediately to every burst of sunshine, every shower of rain: it is sensitive. The marked shrinkage of rivets on cooling is utilised for the pressing together of ship-plates.

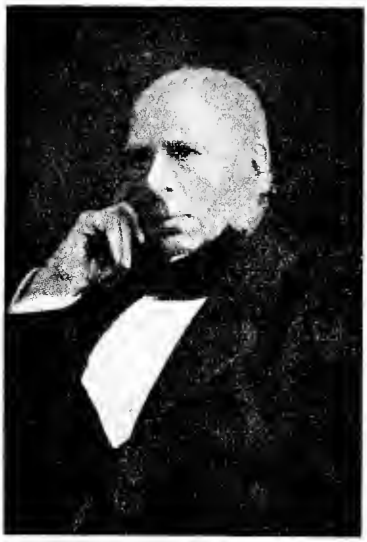
This is the age of iron: from the needle to the anchor. Hard in

(Photo lent by Principal Walter MacFarlane.)
FIG. 17.—Samuel Grice, sixty years a shingler.

FIG. 18.—Steel ingots in the mouth of a smelting furnace.

razors and chisels, soft in horse-shoe nails, it may be wrought as soft as copper, or tempered hard enough to scratch glass, for it hardens or softens according to the way it is heated. It contains carbon from a trace up to 1·5 per cent. Iron is employed commercially in two main forms, wrought iron and steel. The tensile strength of wrought, or, as it is sometimes called, malleable, iron runs from 18 to 25 tons per square inch, and the elongation capacity from 10 to 25 per cent. on an 8-inch piece; while ordinary steel varies in tensile strength from 24 to 50 tons, and the elongation from 15 to 36 per cent.: thus steel is stronger and more elastic than wrought iron. For these

FIG. 19.—Tapping of steel from a furnace at nearly twenty times the temper of boiling water.



(*Photo by Maull & Fox, London.*)

FIG. 20.—Henry Bessemer, English engineer, 1813–1898.

(*After Walter MacFarlane.*)

FIG. 21.—William Siemens, British inventor, 1823–1883.

figures the reader is indebted to the manager and assistants of the Dalzell Iron Works, Motherwell. In the process of manufacture wrought iron is not heated so high as in the preparation of steel, where the metal is raised to a temperature of about 1000° Centigrade ; at that heat the iron melts, and, after simmering for a while, leaves the furnace in a molten stream free from slag or silicate. But in the

(From a photo lent by John Murray, London.)

FIG. 22.—Sidney Gilchrist Thomas, 1850–1885, discoverer of basic-steel process, and so founder of the German iron trade.

manufacture of wrought iron the temperature of the furnace is some four to five hundred degrees lower, the metal remains a pasty, semi-solid mass all the time ; it is then wrought or puddled into a sticky ball, and the slag expelled by a ponderous steam-hammer, which pounds, squeezes, and squelches it out. It is warm work for the men.

The difference between steel and iron is determined by the different heatings they receive and the amount of work done in rolling the steel ingot into the form of a bar or plate. The highest strength is found in wire, being the finished product on which most work has been

expended, its tensile strength, according to J. A. Ewing, being as high as 100 or even 120 tons per square inch. The tensile strength of nickel-chrome steel can be raised from 40 to 100 tons per square inch by difference in heating treatment alone. Steel usually contains more carbon and manganese but less silicon and phosphorus than iron wrought.*

The changing condition of iron according to heating is evident in the process known as annealing or re-heating. The housewife anneals her glass tumblers by gradually heating and cooling them in her fish-kettle. And it were useless to hammer out steel castings and then find they had gone brittle, so the iron is stimulated by re-heating into fresh elasticity and strength. Mooring chains weakened and over-strained can thus be restored.

Extreme Cold.—The action of metals in severe cold was examined by James Dewar and his helpers. They found many interesting differences in the behaviour of the metals at ordinary and low temperatures; for example, the temperature of liquid air, for air does become liquid when you cool it far enough. In ordinary air silver is a better electric conductor than copper, but at the temperature of liquid air copper is a better electric conductor than silver.

Again, the tenacity of gold is doubled at a temperature of $-180°$ Centigrade (one hundred and eighty degrees below the freezing point of water).

C. *Light and Darkness Action.*

The salts of silver bromide are peculiar, in that when influenced by light they change very rapidly. If we spread a film of them upon

* Composition of Wrought Iron compared with Steel.
(After Walter MacFarlane.)

Constituents.	Chemical Symbols.	Good Wrought-iron Shaft.	Mild Steel for General Engineering Purposes.
Carbon	C	trace	0·18
Silicon	Si	0·12	0·02
Sulphur	S	0·04	0·05
Phosphorus	P	0·21	0·05
Manganese	Mn	trace	0·50
Cinder or slag	..	1·30	none
Iron (by difference)	Fe	△	△
		100·00	100·00

* Phosphorus in the cinder, 0·05.

a plate of glass, silver falls upon the plate wherever light has acted. We then obtain a "photograph," a "negative," which again, on being printed, gives us the finished photo.

But Moser found that this change on exposure to light action was not confined to salts of silver, but silver itself; copper and glass give a similar result. He took polished plates of these metals, cleaned them, and fixed over them—but without touching—black tablets with letters cut out. He them placed them in the sun for some hours. The plate of silver, or copper, or glass was then cooled and held over heated mercury. "To my great delight," he records, "a distinct

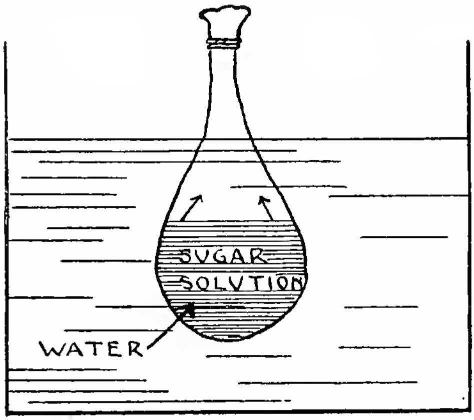


FIG. 23.—The attraction of water into a sugar solution through a bladder.

image of the screen was produced where the sunlight had acted," mercury having been attracted thither.

Later, a Frenchman, Gustav le Bon, found that metals exposed to sunlight afterwards affected a photographic plate, even in the dark, and even through an opaque film, such as ebonite. He gave this action the arresting title of "Black Light." Metals after being sunlit change also in electric condition, though not all to the same degree; for upon the testing electroscope, zinc and aluminium act more rapidly than do gold, silver, platinum, and mercury.

D. *Physico-Chemical Action.*

Take a 1 per cent. solution of sugar and pour it into a bladder. Place the bladder in pure water. The sugar solution then attracts the water, which passes from the outside to the inside of the bladder,

until the pressure inside may be so great as even to burst the bladder.

This swelling action was used by the builders of the Egyptian pyramids for splitting the rocks, driving wedges of wood into them and pouring water thereon.

It has been emphasised by many modern scientists in explanation both of chemical and vital facts.

(Photo by Frith, Bristol.)

Fig. 24.—Great Pyramid and Sphinx of Egypt.

E. *Electro-Chemical Action.*

Take a solution of hydrochloric acid in water. Pass a shock through this solution from an electric battery. The solution changes. A green-yellow gas, "chlorine," comes away at the end where the electric shock enters; and an extremely light colourless gas, "hydrogen," comes away at the other end where the electric shock leaves.

Opposite Action.

The changes of the elements are manifold. They form the province of the chemist. Among the most baffling of them are the changes in opposite direction, a few instances of which may be here taken :—

Mechanical Action.—A wire changes weight on being drawn.

Maclean has tried this, and gives the following figures for metals :—

	Specific Gravity of Undrawn and Drawn Wires.
Steel annealed	7·78 7·762
Aluminium	2·8 2·796
Nickel	8·9 8·85
Lead, pure	(1) 11·25 (2) 11·35 11·15 11·357
Platinoid (an alloy of nickel, zinc, copper, tungsten)	8·74 8·78
Manganin (an alloy of copper, manganese, and nickel)	8·515 8·58
Copper (average of six qualities)	8·906 8·985

Here some bodies, *e.g.* aluminium, become lighter on being drawn, others, *e.g.* copper, became heavier.

This change in opposite directions may occur even in two specimens of the same metal, as seen in the case of the lead.

Heat Action.—The metal copper on being heated from room temperature to red heat *increases* its resistance to the passage of electric action ; the very reverse result is seen in the carbon filaments of our electric globes, for when heated to red heat they diminish in resistance.

The housewife's jelly, like most jellies, sets on cooling ; but casein, the chief albuminous body in milk, after being treated with sodium and calcium, sets on heating.

Dewar advances these next figures as the "breaking stress in pounds of cast metallic pieces," $\frac{1}{5}$ inch in diameter, at normal and extremely low temperatures :—

	15° C.	182° C.
Tin	200	390
Lead	77	170
Zinc	35	26
Bismuth	60	30

So we see, while tin and lead change in one way, zinc and bismuth change in the other.

Chemical Action.—Some bodies become warmer, others colder, on mixing.

Mix lime and water—they heat.

Mix common salt and water—they cool.

Try it with a thermometer to see.

When aluminium is fused with copper, the alloy heats.

When lead is fused with tin, the alloy cools.

Electric Action.—When solutions of finely-divided metals are made in water by passing an electric action from metal terminals through the fluid, particles of the metals wander into the water, and these suspended particles move: those of gold and platinum move *with* the current, those of iron and aluminium move *against* it.

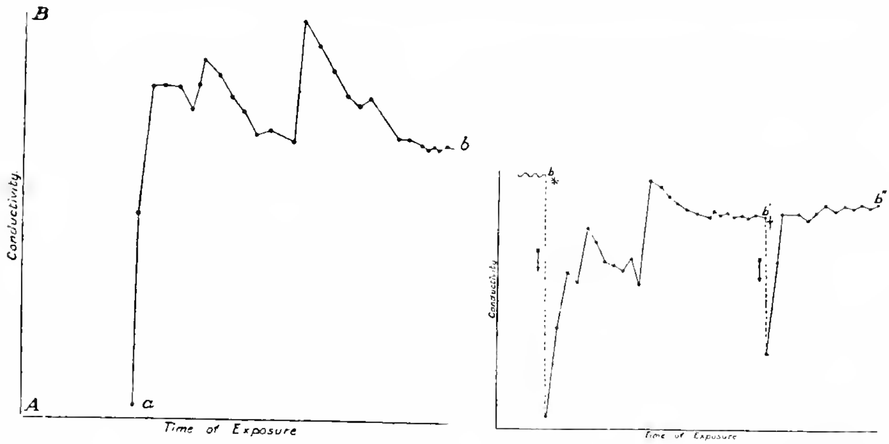
In Michael Faraday's view the effect is considered as *essentially*

FIGS. 25 and 26.—Michael Faraday's view of the electric action on a fluid substance.

dependent upon the *mutual chemical affinity* of the particles of opposite kinds. Particles *a a* (fig. 25) could not be transferred or travel from one pole N towards the other P unless they found particles of the opposite kind *b b* ready to pass in the contrary direction; for it is by virtue of their increased affinity for those particles, combined with their diminished affinity for such as are behind them in their course, that they are urged forward; and when any one particle *a* (fig. 26) arrives at the pole, it is excluded or set free, because the particle *b* of the opposite kind, with which it was the moment before in combination, has, under the superinducing influence of the current, a greater attraction for the particle *a* which is before it in its course, than for the particle *a* towards which its affinity has been weakened.

The Hindoo, Jagadis Chunder Bose, has made a prolonged study of the sensitiveness of the elements to electric shock. Those substances becoming more conducting upon an electric shock he calls *positive*; those becoming more resistant upon electric shock he calls *negative*. On shock, iron and magnesium become more conducting, but potassium and arsenic become more resistant. Iron and magnesium fatigue in the plus direction, potassium and arsenic in the minus; they return towards normal on heating or on gentle tapping.

The change in opposite ways may occur even in one and the same body. In the case of magnesium, Bose tells us " It is sometimes



FIGS. 27 and 28.—Stimulus by heat and mechanical action upon iron fatigued by electric shocking. (1) Simple shock. (2) Showing sudden diminution of electric conductivity on heat and tapping.

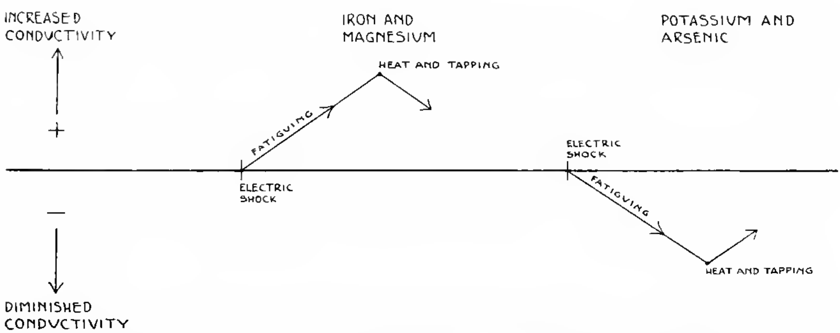


FIG. 29.—Opposite action of four elements to electric shock and recovery on heat and tapping. Diagram. (1) Iron and magnesium. (2) Potassium and arsenic.

possible so to adjust matters that one flash of radiation produces a diminution of resistance, the very next an increase of resistanee. Thus a series of flashes may be made to produce alternate throws of the galvanometer needle."

The same opposite action is seen in magnetic attraction and repulsion.

3

Electro-magnets attract iron but repel aluminium, for iron moves towards such a magnet, but aluminium moves away from it.

In London some years ago a striking demonstration of this was seen in the railway engineered by Monsieur Bachelet. Bachelet's car

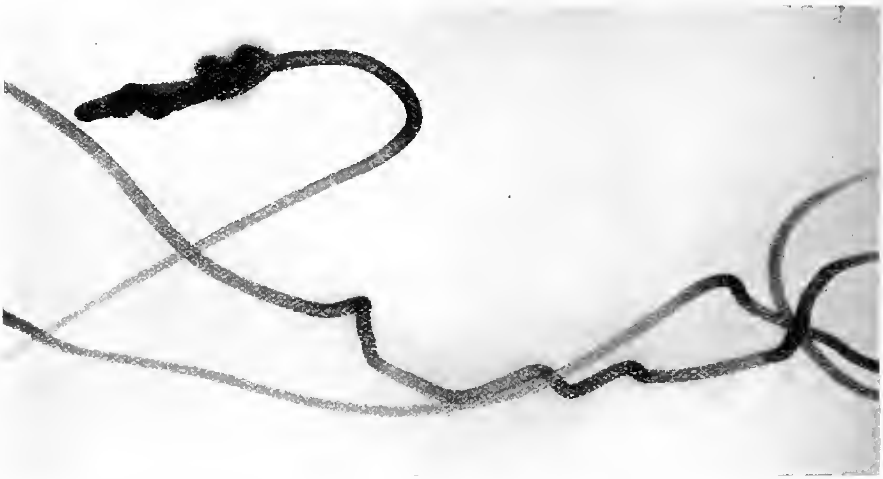


FIG. 30.—Exposure of one photo-film to several lightning flashes in a storm at night. Observe the silver salts have acted black instead of white, and white instead of black.

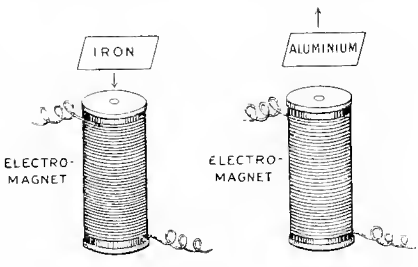


FIG. 31.—Iron moves towards an electro-magnet, aluminium moves from it.

was built of iron, resting on an aluminium bedplate; it ran upon a track of great electro-magnets. On the magnets being set in action the bed-plate, of *aluminium*, rose from off the track and bore up the weight of the car till it became as light as a feather, while the *iron* of the car itself was drawn along the track to a magnet-tunnel, and then on to one after another tunnel at lightning-like velocity.

For illustrating this principle a small aluminium plate was placed over an electro-magnet, and on the magnet being set in action this plate bubbled up on nothing, like a puff-ball on the fountain of a shooting-range. Only, in this case, there was no water; you could pass your hand below between the plate and the magnet. And when you thrust the weight of your arm down upon the plate, you managed only to force it so far towards the magnet, for you felt the plate thrusting and struggling hard upwards against you: on nothing—at least on nothing visible.

Such opposite properties, whether seen in mechanical action, heat action, chemical action, or electro-magnetic action, seem at first difficult to understand, but, as Chunder Bose remarks, "about their reality there can be no doubt." They merit more attention, for their reason is unknown.

Michael Faraday recognises opposite action in the case of the electric current in definite terms, for he says :—

"*Judging from facts only*, there is not as yet the slightest reason for considering the influence which is present in what we call the electric current, whether in metals or fused bodies or humid conductors, or even in air, flame, and rarefied elastic media—as a compound or complicated influence. It has never been resolved into simpler or elementary influences, and may perhaps best be conceived of as *an axis of power having contrary forces, exactly equal in amount, in contrary directions.*

"I hope I have now distinctly stated, although in general terms, the view I entertain of the cause of electro-chemical decomposition, *as far as that cause can at present be traced and understood.* I conceive the effects to arise from forces which are *internal*, relative to the matter under decomposition—and not *external*, as they might be considered, if directly dependent upon the poles. I suppose that the effects are due to a modification, by the electric current, of the chemical affinity of the particles through or by which that current is passing, giving them the power of acting more forcibly in one direction than in another, and consequently making them travel by a series of successive decompositions and recompositions in opposite directions, and finally causing their expulsion or exclusion at the boundaries of the body under decomposition, in the direction of the current, *and that* in larger or smaller quantities, according as the current is more or less powerful. I think, therefore, it would be more philosophical, and more directly expressive of the facts, to speak of such a body, in relation to the current passing through it, rather than to the poles, as they

are usually called, in contact with it; and say that whilst under decomposition, oxygen, chlorine, iodine, acids, etc., are rendered at its negative extremity, and combustibles, metals, alkalies, bases, etc., at its positive extremity. I do not believe that a substance can be transferred in the electric current beyond the point where it ceases to find particles with which it can combine."

The Rainbow.

Finally, consider the rainbow.

When sunlight passes through a water-cloud or a piece of crystal we see not white light, but a sequence of colours—red, orange, yellow, green, blue, indigo, violet. Now, each metal displays its own distinctive colour. Place the soft, tin-white metal thallium in the flame of a Bunsen burner, and then examine the flame through a crystal: a clear-cut band of light appears in the green of the rainbow, the band of thallium. Substitute now sodium for thallium, and the yellow, the famous "D line" of soda appears. Try next lithium for soda: a clear-cut band of light appears in the red, the band of lithium. And we can tell whether even a far star possesses thallium, soda, lithium, and other elements by examining its lines of light through the crystals of the spectroscope. These several bands are each distinct, but distinct upon a continuous rainbow.

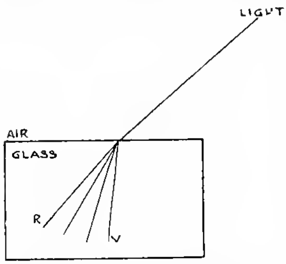


Fig. 32.—The divergence of light in passing from one medium into another.

The three forms of matter—thallium, sodium, and lithium—are not nearly so distinct as they at first sight appear. Could the observer trace these elements back in centuries as in seconds, might he not see these three separate bands slowly moving towards one another and fusing into one, like the pictures of a stereoscope? Three elements arising from one.

In the words of the famous chemist, Wilhelm Ostwald: "We can scarcely avoid the conception of a simple pro-matter whose diverse grouping has conditioned the diversity of the elements." Water and earth are both sprung from the primeval paste.

Which brings us back to our list of elements, and the question arises, Are things as distinct as they seem?

From Cloud to Star.

That question has been broached often, and along a variety of paths. Following upon the work of Johann Kepler (1571–1630) on the elliptical revolving in space of our planets around the sun, and the calculation by Isaac Newton (1642–1727) of the motion of the moon to the earth—resulting in the establishment of the law of gravitation, and proving that a stone in falling does not only

(*With the permission of John Murray, London.*)

Fig. 33.—Isaac Newton, English natural philosopher.

move towards the earth, but also the earth moves towards the stone, though with their different masses the measurement of the earth is not so evident as that of the stone. Immanuel Kant (1724–1804), a German of Scottish ancestry, outlined a speculation of deep height and beauty, the evolution of the stars from out of mist. Sir William Herschel (1738–1822), pursuing this conception, described over 2500 different star-clouds. The idea was further supported by the French astronomer Pierre Simon Laplace (1749–1827).

Look up on a clear night and view the Milky Way, with its countless myriads of worlds, the great and distant Sirius, the close cluster

Fig. 34.—Immanuel Kant, of Königsberg, at the age of 67.

Fig. 35.—William Herschel, British astronomer, discoverer of the planet Uranus.

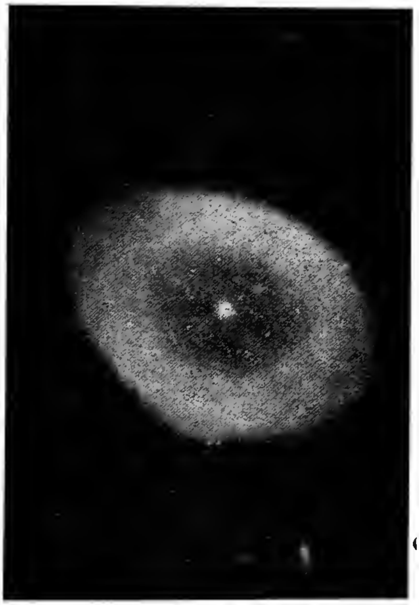
Fig. 36.—Laplace, French astronomer.

(*By permission of the Yerkes Observatory and the proprietors of the " Encyclopædia Britannica."*)

FIG. 37.—The nebula in Orion.

(*Lent by Director Campbell of the Lick Observatory, California.*)

FIG. 38.—Nebula in Canes Venatici, 1899, May 10. Exposure of 4 hours.



(*Lent by Director Campbell of the Lick Observatory, California.*)

FIG. 39.—The ring nebula in Lyra. Photographed with the Crossley Reflector. Negative by A. G. Curtis.

(*After a photo by Isaac Roberts, Crowborough, Sussex.*)

FIG. 40.—Star clouds in the Pleiades.

of stars we call the Pleiades, and the mighty quadrilateral with its triplet belt and hanging sword and bow, Orion. And in the Milky Way are far-flung clouds, some dark, some light; some faint and diffuse, others brighter in parts; others with bright points—commencing stars; still others with brilliant spots; till, in some systems, the cloudiness

(By permission of the Yerkes Observatory and the proprietors of the "Encyclopædia Britannica.")

Fig. 41.—The nebula in Andromeda.

disappears, leaving the stars naked, as in the Pleiades: whirling in spirals like a tidal river, coiling into suns and earths and moons.

In the words of Herschel :—

> "It is highly probable that every state of the nebulous matter is the result of the action of gravitation upon it while in a foregoing one, and by such steps the successive condensation of it has been brought up to the planetary condition."

The earth moves round the sun, the sun and its planets swings in the Milky Way, and what if the Way itself be but a network sweeping with distant others round some centre beyond our ken! Or to quote the language of Kant himself:—

> "The theory (of the nebulous stars) opens up to us a view into the infinite field of creation, and furnishes an idea of the work of God which is in accordance with the infinity of the great Builder of the universe. If the grandeur of a planetary world, in which the earth, as a grain of sand, is scarcely perceived, fills the understanding with wonder, with what astonishment are we transported when we behold the infinite multitude of worlds and systems which fill the extension of the Milky Way! But how is this astonishment increased when we

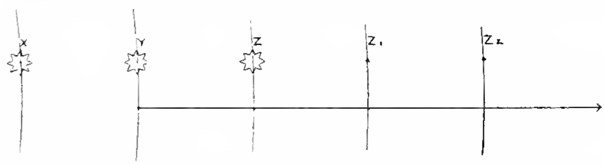


FIG. 42.—Illustrating the infinity of the stars.

Suppose yourself inside a great football sphere; you may blow out the sphere as far as you like, but always there is an outside to it, beyond even the furthest star of your ken; and the outside distances are just as real as the inside ones.

> become aware of the fact that all these immense orders of star-worlds form but one of a number whose termination we do not know, and which perhaps, like the former, is a system inconceivably vast, and yet again but one member in a new combination of numbers! We see the first numbers of a progressive relationship of worlds and systems; and the first part of this infinite progression enables us already to recognise what is to be conjectured of the whole. There is here no end but an abyss of a real immensity, in presence of which all the capability of human conception sinks exhausted, although it is supported by the aid of the science of numbers. The wisdom, the goodness, the power which have been revealed is infinite; and in the very same proportion are they fruitful and active. The plan of their revelation must therefore, like themselves, be infinite and without bounds."

William Herschel speaks of "an infinitely extended existence."

Laplace conceives of " a fluid of immense extent," and goes on to say of this solar atmosphere :—

> " In the assumed primitive condition of the sun it resembled these nebulæ which are shown by the telescope to be composed of a more or less brilliant nucleus, surrounded by nebulosity which, in condensing towards the surface of the nucleus, transforms it into a star. If by analogy we conceive of all the stars being formed in this manner, we may imagine their earlier nebular state, itself preceded by other states in which the nebular matter was more and more diffuse, the nucleus being less and less luminous. By going back as far as possible we thus arrive at a nebulosity so diffuse that its existence could hardly be suspected."

SURVEY: SECTION 2.

FROM ELEMENT TO PLANT AND ANIMAL TISSUE.

Some say the flowers and trees, the fish and fowl, the animals and man, these inhabit the surface of the earth and are alive. But the coal, the minerals, the metals, and all within the bowels of the earth are dead ; for they neither move, nor breathe, nor grow, nor fatigue nor recover therefrom, nor marry and reproduce.

Others maintain not so.

Water moves and grows into steam.

Coal breathes, for in burning it takes up the gas oxygen and gives off carbonic acid gas, like any plant and animal.

A motor cycle fatigues as it climbs a hill, yet it recovers its power at the summit.

And it is not every plant and animal that reproduces.

These last make experiments, burning plants and animals, and resolving them into elements—oxygen, nitrogen, hydrogen, carbon, sulphur, phosphorus, and iron.

Quincke brought a drop of almond oil and chloroform on to the surface of water and allowed a small drop of a 2 per cent. solution of soda to approach the drop of oil, which then moved and twisted itself like a living thing. And Bütschli observed such oil and lather movements to continue of themselves and without interference for several days on end.

They compare element and tissue chemically : thus the salt known as potassium bromide is used as a restrainer in the development of photographic plates ; it is also employed to restrain and control epileptic fits in man.

They test elements and tissues with heating and cooling and find them similar.

Compare the chemical union of the elements hydrogen and purple iodine with the growth of frogs' eggs.

Hydrogen and iodine unite into hydrogen iodide :

At 440° C.	(boiling sulphur)	the union takes	*hours.*
,, 350° C.	(,, mercury)	,, ,, ,,	*days.*
,, 265° C.	(,, oil)	,, ,, ,,	*months.*
,, room temperature		,, ,, ,,	*years.*

(Lemoine.)

Frogs' eggs develop :

At 24° C. in 1 day.	At 10° C. in 3·16 days.
,, 20° C. ,, 1·2 days.	,, 6° C. ,, 4·7 days.
,, 15° C. ,, 2 days.	

(Oscar Hertwig.)

They compare the ferment action of elements and plants and find them similar :—

1. Mix and warm the gases oxygen and hydrogen : they unite slowly to form water. But on adding a very minute quantity of the metal platinum, even as dilute as 1 of platinum in 70,000,000 parts of water, they unite rapidly.

2. Yeast hastens the fermenting of starches and sugars in barley to form alcohol, as in the brewing of beer.

They compare the action of elements and tissues on electric shock and find them similar :—

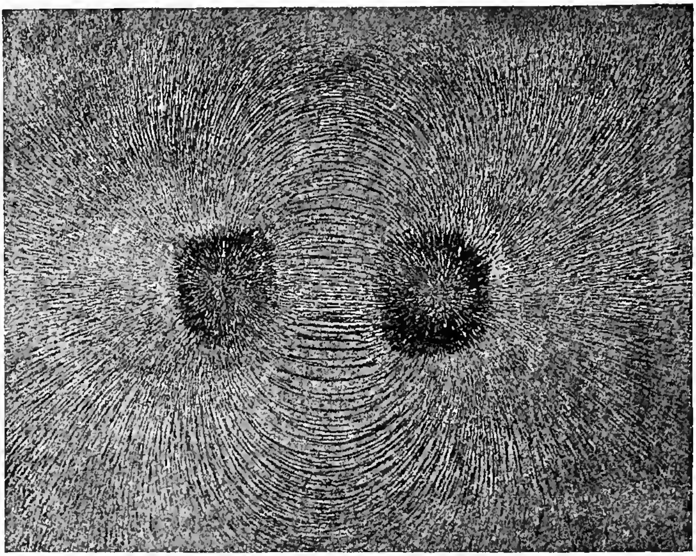
> Iron filings fall into definite lines when shocked by electro-magnetic action (fig. 43).
>
> Tiny living beings do the same (fig. 44).
>
> The metal potassium jerks and recovers on electric shock (fig. 45).
>
> The muscle of the frog's leg also jerks and recovers on electric shock (fig. 46).

Gold and iron in watery suspension take opposite directions on electric shock.

Tiny living beings—Ciliata and Flagellata—do the same, and

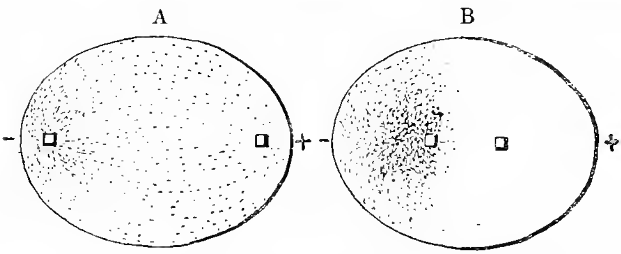
on the shock being reversed they cross over and reverse like men in the game of Halma.

The dividers of element from tissue, the uniters of element to



(*After J. J. Thomson, of Cambridge.*)

FIG. 43.—Card set over a magnet and iron filings scattered thereon. Note the direction of the tubes of action.



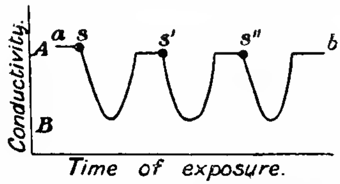
(*After Verworn and Oscar Hertwig.*)

FIG. 44.—The minute organisms Paramœcia.

The organisms are in water; in response to the constant current they arrange themselves in curves, make for the negative pole, and finally congregate beyond it ("galvanotropism").

tissue—let them fight it out. The dividers have never proved element to be distinct from tissue; the uniters have never yet made a plant, or an animal, or a man out of clay.

Arrhenius and Kelvin fancied that life may have been borne to earth upon meteorites or starry particles. But this view merely displaces the problem.



(*After J. C. Bose.*)

Fig. 45.—Change of quality of potassium upon electric shock.

A represents the conductivity of the fresh specimens; the thick dots *s*, *s'*, *s''* the individual shocks, at each of which there occurs a sudden diminution of electric conductivity.

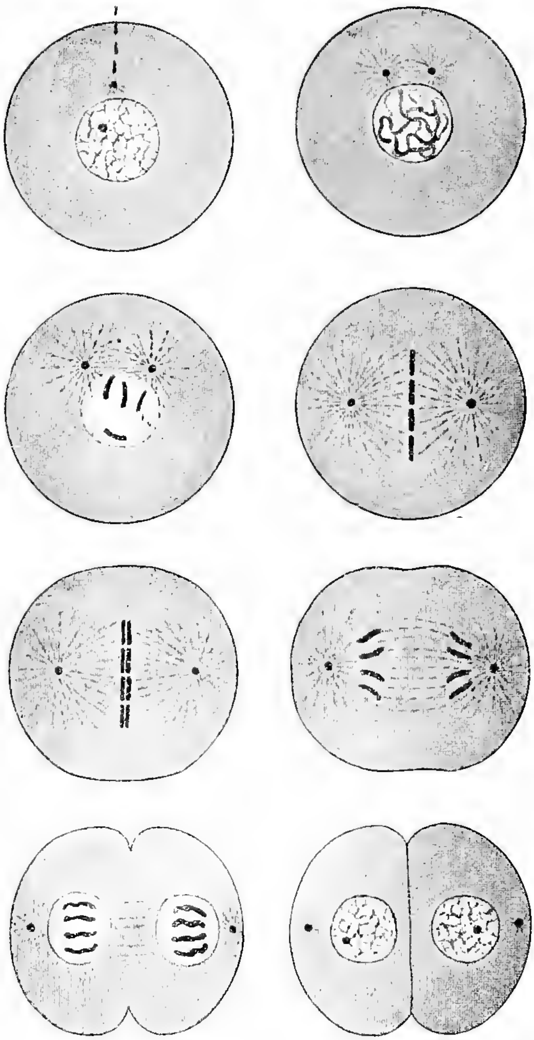
Fig. 46.—Carbonised paper on a revolving drum, and muscle twitches of a frog shown thereon. Each time the drum swings round the muscle contracts, then laxes. But with each successive shock it recovers more and more slowly, less and less completely ("fatigue").

Let us be content with the ancient verdict: Of dust thou art, and unto dust thou shalt return. And let us pass on.

SURVEY: SECTION 3.

TISSUE PLANT AND ANIMAL.

Consider the changes of plant and animal and man. How shall we compass so great a field, each controlled by experts? The embryologist admiring the growth of a man out of a minute piece of apparently simple jelly, $\frac{1}{120}$ of an inch in diameter, or detecting



(*After William Leche.*)

FIG. 47.—Stages by which first cell becomes two.

The magnetic dot divides. The dark-staining filaments of the inner kernel form a spiral, which then becomes the hereditary rods; these rods appear to divide, and one half go one way, another half go another, moving towards their respective dots. Hence appear two kernels and two cells instead of one.

Fig. 48.—William Harvey, discoverer of the circulation of the blood.

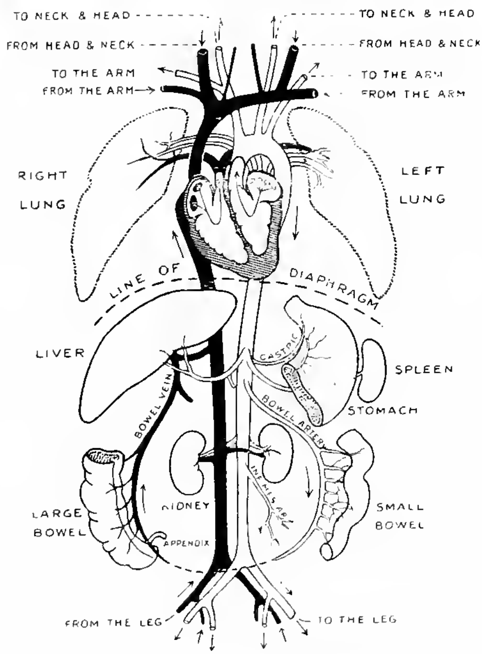


Fig. 49.—Course of the blood in the heart.

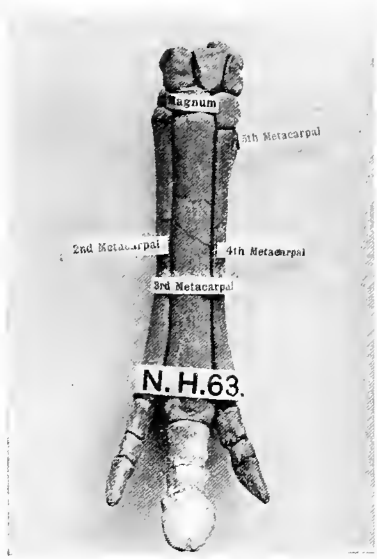
the first pulse of the chick's heart. The anatomist, like William Harvey (1578–1657), tracing how the heart pumps the blood fresh from the lungs to bowel and bone and brain and muscle by the arteries and circulates it back again by the veins. The evolutionist

(From a photo lent by F. A. Lucas, Director of the American Museum of Natural History, New York and W. D. Matthew, Curator of the Department of Vertebrate Palæontology in the same.)

FIG. 50.—Possible evolution of foot and horse's hoof.

Side views of six stages, called Eohippus, or early horse, Mesohippus, Miohippus. Meryohippus, Hipparion, Equus. Eohippus had three toes and a rudiment on the hind foot: two toes are here seen. The gradual drawing up of the side toes and the steady change of the finger into hoof is evident.

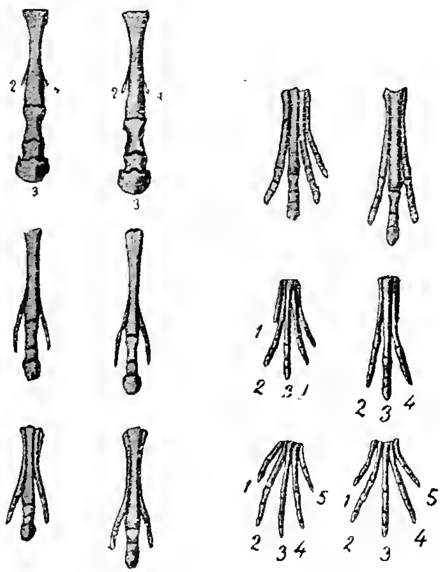
tracing the creation of, say, the horse: the early horse (Eohippus), about the size of a fox, running on its hands and feet, with four working fingers in the hand and three fingers in the foot: the modern horse larger. And in the series Eohippus, Mesohippus, Miohippus, Protohippus, Pliohippus, to the modern horse Equus, he sees a



(*Photo by H. G. Herring.*)

FIGS. 51 and 52.—Evolution of horse's hoof.

65. Hyracotherium, or Protohippus. 63. Mesohippus. From the department of Natural History, South Kensington.



(*After Thomas Huxley and William Leche.*)

FIG. 53.—The feet and bone-limbs of the horse compared with those of its supposed ancestors.

gradual increase in the size of the horse, along with a steady reduction in the number and size of its fingers. He tells us the nail of the mid-finger has " evolved " into a hoof.

Or the experimental " biologist " successfully crosses the starfish with the sea-urchin, and describes the new tissues he has called forth.

The number of such facts is endless. Who shall guide us through them ?

Let us follow Charles Darwin (1809–1882) for a while.

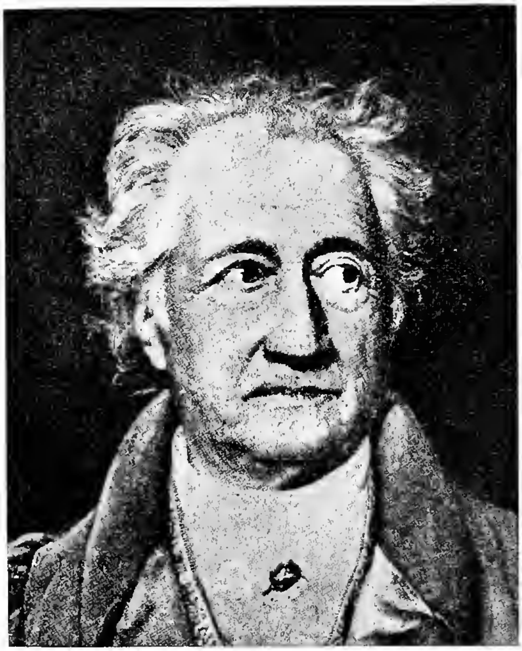


Fig. 54.—Goethe, 1749–1832. One of the pioneers of the evolution theory.

Charles Darwin and Natural Selection.

Darwin ! That was the man who said we sprang from monkeys, was he not ? This grasps the view of Darwin that the various forms of plant and animal are not fixed but have changed the one into the other, but it loses sight of the principle he worked to comprehend—the Origin of Species by Natural Selection, the survival of the fittest, " the Preservation of Favoured Races in the Struggle for Life."

Like all great principles it is easy. Firstly, a selection is made by Nature every day. A female herring brings forth 40,000 eggs a year, and if it does so for ten years it produces 400,000. The total number of herrings is not increasing greatly. If two of these survive to carry on the race, what happens to the other 399,998? They are "eliminated" and devoured: they are lost.

The elephant again is a slow breeder, beginning at the age of thirty and continuing till about ninety, but breeding so slowly that

Fig. 55.—Charles Darwin.

The medallion in the north aisle of Westminster Abbey.

in the sixty years only some three pairs of young ones are produced. Yet if all the young had survived till they were capable of reproducing, elephants would to-day be swarming over the earth in millions, crushing out the other races before them. As this is not the case, we conclude that many elephants die.

Darwin saw there was a difference probably between those that died and those that survived. He perceived that if 1000 young creatures are battling in a fight for existence against each other and against the "forces of Nature," then those that *do* win through

are not usually the weakest, but rather the strongest or cleverest or most adaptable. One hundred and forty-six human beings were thrust into the Black Hole of Calcutta; only twenty-three issued alive in the morning, and these twenty-three were not the weakest.

Darwin records another instance in 1864. On 24th May of that year there was a severe frost which killed and blackened 378 out of 390 scarlet runner plants in his garden; four days later a still more severe frost occurred, and only three plants survived the ordeal:—

> "It was impossible to behold those three plants, with their blackened, withered, and dead brethren all around, and not see at a glance that they differed widely in constitutional power of resisting frost."

Here the quality of resistance to external cold was selected. More particular qualities could also be picked out. Thus Jameson found a small sandy island, the North Bull, on the north of Dublin Bay, thickly populated with a mouse lighter in colour than those of the mainland from which they were derived; owls visited the island, and had apparently picked off those not blessed with a pale buff fur.

In a part of Virginia the pigs are all black, for the white ones lose their hoofs by feeding off the poisonous roots of certain plants. The inefficient go to the wall. In every generation the quality most useful for life is selected. The Polar bear is white, because the brown or black bears could not stalk their prey unseen, and so died of hunger. The useful was kept, the useless rejected.

The *Challenger* Expedition, and later the Deep Sea Expedition of 1898–99, found that many oceanic fishes, crustaceans, and molluscs possess lanterns, complex structures reflecting the light and assisting the animal to find its food or attract its prey; now, on the argument of natural selection, forms developing such structures would be advantaged in the race, and ultimately be selected. The owl has large eyes, for those with the biggest eyes caught the most mice.

Mr Belt, describing the armies of foraging ants in Nicaragua, which devour every insect they encounter, says:—

> "I was much surprised with the behaviour of a green, leaf-like locust. This insect stood immovable among a host

of ants, many of which ran over its legs without even discovering there was food within their reach. So fixed was its instinctive knowledge that its safety depended on its immovability, that it allowed me to pick it up and replace it among the ants without making a single effort to escape. This species closely resembles a green leaf."

(After Chun, Sir John Murray, and Dr Hjort (Messrs Macmillan).)

FIG. 56.—A deep-sea mollusc.

These qualities of keeping still and of mimicry to surroundings have arisen, because in each generation natural selection picked out these locusts that kept still and were likest leaves, and so preserved them. The common shore crab does the same—lies low when attacked, and looks for all the world like a stone.

Or again, the terrifying eye-marks on the caterpillar, the rattle of the rattlesnake, the mimicry of the wasp-like moth to the wasp, have all arisen because such qualities scared attackers away, and so saved the owners from being selected out by death. Man throws stones and walks erect because the early men who failed to alarm attacking beasts by so rising and throwing stones were devoured.

The sloes, the buckthorn, and the barberry have sensitive leaves, so that when touched they draw behind a rampart of thorns, just of the right length to protect them. If they had no thorns they would be eaten by cattle. One crow pairs with another to make a nest and family. The crow families unite to form a defensive rookery, for stragglers were invariably pounced on by hawks and other birds of prey. And sometimes the process of selection affects man on a vast scale. The 1883–87 outbreak of cholera in the South of Europe caused about 250,000 deaths;

Fig. 57.—Mimicry to surroundings.
Pool on the sea-shore, Firth of Clyde, with sea-weed, shells, and small stones.
Puzzle, find the crabs.

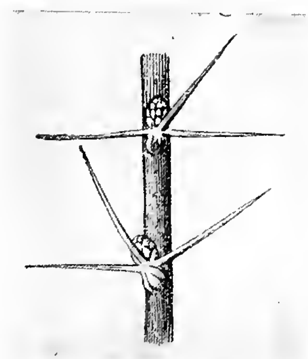
(After W. P. Pycraft, "The Infancy of Animals.")

Fig. 58.—Mimicry. Nestlings of the common tern.

Fig. 59.—End of rattle-snake's tail.

another invasion followed in 1892–95, and spread by road and rail from India to Russia and thence over Northern Europe with great rapidity and a high death-rate, the organism being very virulent. Yet the South of Europe escaped—the predisposed specimens had been already weeded out by the earlier outbreak.

(Photo by J. H. Leonard.)
FIG. 60.—Mimicry of the wasp-like moth to wasp. Natural History Department, South Kensington.



(After Kerner and August Weismann.)
FIG. 61.—Twig of the barberry in spring.

Proceeding on masses of such facts, Charles Darwin recognised two factors in Nature :—

(1) No two members of a family are exactly alike : natural diversity.

(2) A survival of the fittest : the best being selected to transmit their qualities to others.

Darwin also applied the same idea to the individual organs and parts :—

"When an animal has to struggle throughout its life with many competitors and enemies under circumstances inconceivably complex and liable to change, modifications of the

most varied nature in the internal organs as well as in the external character, in the functions and material relations of parts, will be vigorously tested, preserved or rejected."

On the whole, use preserves, disuse destroys.

Darwinism and the Human Brain.

And the predominance of such an organ as the human brain is attributed to the process of evolution by survival. In the course of time-evolution there were once little pieces of moving jelly. Each little jelly was built up of grains or particles. All of these grains are sensitive a very little. One fine day a few grains, more sensitive than the rest, happen to collect together, and so permit

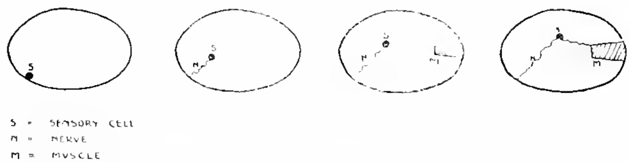


Fig. 62.—Is this the origin of the nerve-reflex, skin to muscle?

that particular jelly to feel a little better than its neighbours. Such sensitiveness pays, and enables that jelliet to evade more quickly the approach of danger or injurious fluids. So it survives. This tendency to gather sensory particles into a sensory mass or cell, upon inheritance, occasions the establishing of a race possessing *sensory cells*. These cells, originally on the surface, gradually sink into the interior as the race develops, but leaving a communicating link in the shape of a *nerve*. Thus, as in the figure, we arrive at a central sensory cell-mass with a nerve to the surface. Also at another point the jelliet develops a contractile material called *muscle*, and this too links up with the central sensory mass, or brain, of the creature A simple *reflex* arc was thus formed, by which the jelliet's sensations can be translated into motion. These forms in which this linking-up process has gone furthest survive.

In relation to the brain the sense organs are similarly produced; perceptions arise, and memory, reason, and will are made possible. But note, all this brain power is still reflex to the environment. Our intellectual processes of to-day appear very complex, but they are just a number of simple reflexes that have run together to form

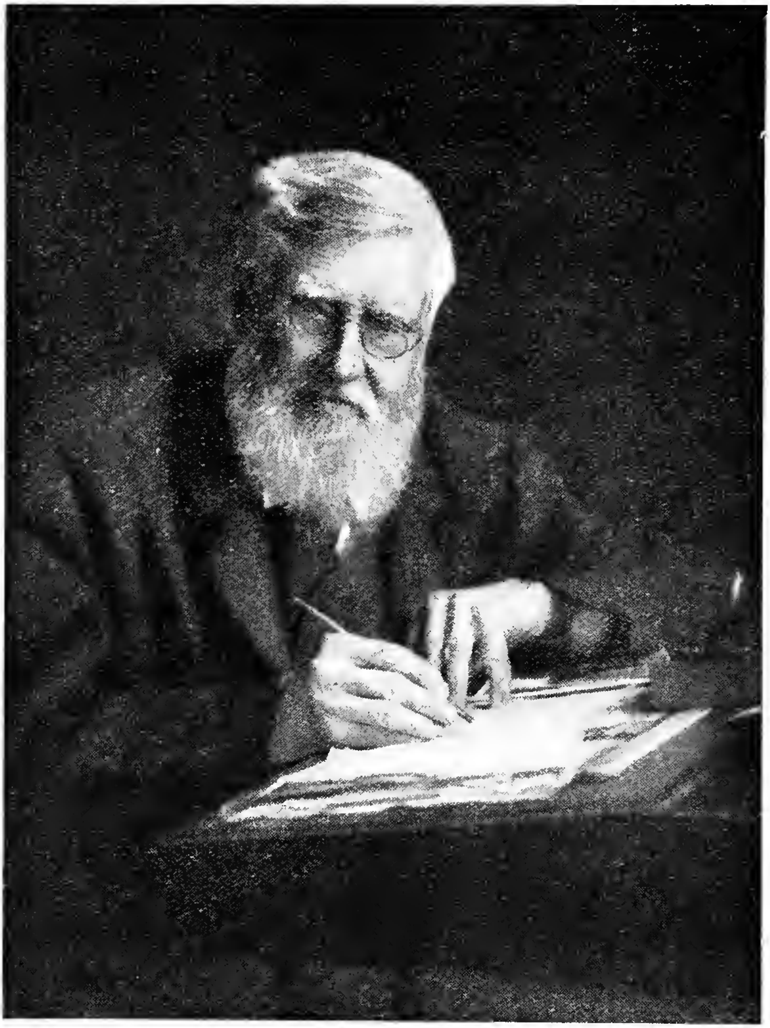
a complex-reflex. It is now some forty years ago since Allen Thomson wrote :—

> " We do not know nerve force as distinct from the nervous fibre. We have good reason to believe that by some modification of that force in its passage through the nerve-cell an afferent nervous impression is converted into an efferent impulse in the phenomena of reflex action. And it does no violence to our power of conception to extend the same view to the more complex mechanism situated within the cerebral ganglia, by which all these motions which we style automatic appear to be regulated without the co-operation or control of will or intelligence. When, however, the same afferent impression which causes a simple reflex or a more complicated automatic action reaches the highest part of the brain and results in sensation or perception, what grounds have we, on any physiological or scientific principle, for asserting that that change which follows is other than a higher manifestation of some nervous property ? "

But some naturalists are not prone to accept the reflex of the brain in its entirety. Alfred Russel Wallace (1823–1913) believes the mathematical faculty to be one of the highest essences of man, and independent of natural selection. And Wallace's criticism is of weight, for he was the co-discoverer with Darwin of the principle of selection ; he, lying fevered on the flat of his back, in a molucca jungle, while Darwin was working patiently in England at his books, his garden and his pigeons ; to Wallace thinking over Malthus' *Essay on Population* " there suddenly flashed the idea of the survival of the fittest " ; he posted his essay " On the Tendency of Varieties to Depart indefinitely from the Original Type " to Darwin, and their chief views coincided even to the heads of their chapters.

> " We have to ask what relation the successive stages of improvement of the mathematical faculty bears to the life or death of its possessors ; to the struggle of tribe with tribe or nation with nation, or to the ultimate survival of one race and the extinction of another. If it cannot possibly have had any such effects, then it cannot have been produced by natural selection.
>
> " It is evident that in the struggle of savage man with the elements and with wild beasts, or of tribe with tribe, this faculty can have had no influence. It had nothing to do with the early migrations of man, or with the conquest and exter-

mination of weaker by more powerful peoples. The Greeks did not successfully resist the Persian invaders by any aid



(*Photo by Debenham & Gould.*)

Fig. 63.—Alfred Russel Wallace, discoverer and land reformer, in the year of his death.

from their few mathematicians, but by military training, patriotism, and self-sacrifice. The barbarous conquerors of

> the East, Timurlane and Genkhis Khan, did not owe their success to any superiority of intellect or of mathematical faculty in themselves or their followers. Even if the great conquests of the Romans were, in part, due to their systematic military organisation and to their skill in making roads and encampments, which may, perhaps, be imputed to some exercise of the mathematical faculty, that did not prevent them from being conquered in turn by barbarians, in whom it was almost entirely absent. And if we take the most civilised peoples of the ancient world—the Hindoos, the Arabs, the Greeks and the Romans, all of whom had some amount of mathematical talent—we find that it is not these, but the descendants of the barbarians of those days—the Celts, the Teutons, and the Slavs—who have proved themselves the fittest to survive in the great struggle of races, although we cannot trace their steadily growing success during past centuries either to the possession of any exceptional mathematical faculty or to its exercise. They have indeed proved themselves to-day to be possessed of a marvellous endowment of the mathematical faculty; but their success at home and abroad, as colonists or as conquerors, as individuals or as nations, can in no way be traced to this faculty, since they were almost the last who devoted themselves to its exercises. We conclude, then, that the present gigantic development of the mathematical faculty is wholly unexplained by the theory of natural selection, and must be due to some altogether distinct cause" (*Darwinism*, chap. xv.).

To which the Western expert would respond: "This is all very well—as literature. But we have never yet ascribed the successes of barbarian peoples to a possession of high mathematical qualities. All we claim is that the mathematical faculty was at every period cropping up in some individuals, and when in modern times the ground became suitable it came to the fore, was seized upon by the environment and fixed. Superior intellects attain their full development only in an intellectual atmosphere. Observe that boy trying to learn the bicycle; you can see the cycle's movements are acting on the boy, in that boy's head; in his lesser brain there lies a balancing centre; and you can reduce the action to a bare equation: Balance-centre of brain $\times$ bicycle movements $=$ learning to ride. The boy is automatic." In such a way natural or external selection comes to

be regarded as the cause even of the highest attributes of human genius.

One quality of tissue especially, namely adaptability, can be selected and transmitted from generation on to generation. As

FIGS. 64 and 65.—Beech trees on the north road.

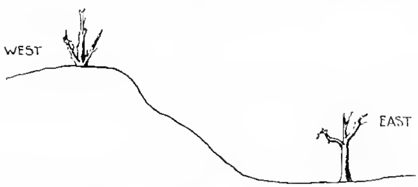


FIG. 66.—The west and east types of beech trees.

to grasp this is to understand Darwin, let us now consider three examples, one from plant, one from animal, and one from human tissue :—

1. *Plant.*—On a certain road to the north there are two rows of beech trees some 200 yards apart. The west row occupies the crest of the ridge, and is more exposed to the prevailing wind ; the east row lies parallel, but sheltered in the hollow. The type of tree west and east is not identical. The two types are shown in the

diagram, the west type with trunks divergent near the ground from a short main trunk, the east type a distinct trunk and branching higher up. The numbers were arranged by three observers as follows :—

West Row.		East Row.	
West type.	East type.	West type.	East type.
17	12	3	27

Thus, in the west row, where the wind falls heavier, there appears a tendency to diverge from the east type of tree. A glance indicates how the west tree will withstand wind better than the east type.

Natural selection argues : This quality in the trees, of adaptability or resistibility, has become stamped on them by outside selection, it being ever the most adaptable forms, the ones most capable of throwing out additional roots and branching low down the trunk that withstood the wind. The two rows of trees were exposed to a difference in the strength of the wind ; they were adaptable ; hence their difference.

2. In animal tissue, perhaps as good an example as any of the selection of adaptability is the inheritance of the capacity to regenerate lost parts. Crabs and lobsters regenerate their lost claws. Spallanzani saw the legs and tail of a salamander grow six times after he had cut them off six times, the animal producing no less than 687 perfect bones in one season. Loeb amputated the head of a polyp, and the beheaded stalk on being suspended in water developed a mouth and tentacles at either end. Von Bulow cut a water-worm into fourteen parts, and got thirteen worms in reply. Regeneration is a strange thing indeed. Cut a small piece of a worm and leave it lying on moist sedge, and it flattens into a jelly-like mass and puts off little growing feelers. John Hunter transplanted the spur of the cock on to its comb, where it grew to such a length that the bird could not touch the ground with its beak. Tornier cut into the budding limb of the developing frog, and two limbs grew instead of one. Or similarly a surgeon transplants the skin from the leg of one man on to the arm of another.

Granted that adaptability can be inherited, it is easy to see how

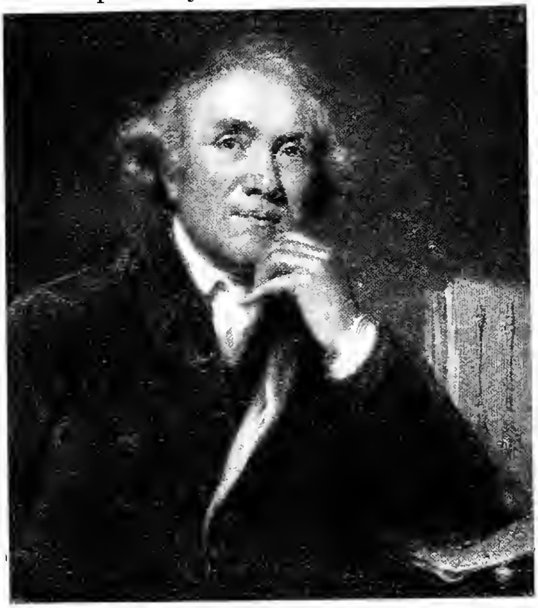
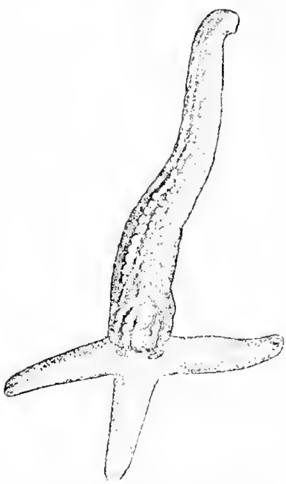


FIG. 67.—John Hunter, British anatomist.

regeneration, which is one form of adaptability, can arise by long centuries of selection. As it was useful for newts, crabs, starfish, and worms to grow off new limbs, the forms adaptable enough to grow them succeeded in the race of life, while those unable failed.



(*After D. S. Jordan and V. L. Kellogg.*)

FIG. 68.—Regeneration of starfish, from single arm.

3. A man goes travelling in lead-pipes with a bag of samples. The weight pulls on the right biceps and the muscle enlarges. Why? Because in early ages those creatures survived whose muscles adapted themselves most quickly to the pushes and pulls of the external conditions. This quality of adaptability being now in the muscle of the man enables it to change in response to weight.

Let us sum up the points so far :—

No two plants or animals are exactly alike.

> In each generation of plant and animal each one has qualities of its own.
>
> The forms most adaptable to external nature win through to hand on their qualities.
>
> External nature may thus be said to control or "select" the qualities of plants and animals.

This last—the control of plants, animals, and man by the forces of external nature—is the essence of Darwinism. This is revealed in his own sentences. In alluding to the changes of wild ducks following on their domestication, he says :—

> "Mr Hewitt found that his young birds always changed and deteriorated in character in the course of two or three

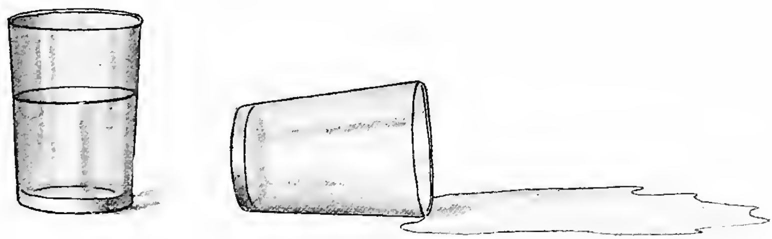


FIG. 69.—A change following push of external environment.

> generations, notwithstanding that great care was taken to prevent their crossing with tame ducks. After the third generation his birds lost the elegant carriage of the wild species, and began to acquire the gait of the common duck. They increased in size in each generation, and their legs became less fine. The white collar round the neck of the mallard became broader and less regular, and some of the longer primary wing-feathers became more or less white."

Here a change occurred in the form of the wild duck following on a change in the external environment. And Darwin considered that every change in plants and animals is the outcome of changed conditions of life. Or, to put the case under another point of view, if it were possible to expose all the individuals of a species under many generations to absolutely uniform conditions of life, there would be no change (*Animals and Plants*, vol. ii. p. 242).

When a change does occur it is really an accident, a casual happening :—

> "Man could make nothing of selecting plants and animals unless their parts happened to vary under domestication" (*Animals and Plants*, vol. i. p. 233).

Or again:

> "That species have a capacity for change will be admitted by all evolutionists; but there is no need, as it seems to me, to invoke any internal force beyond the tendency to ordinary variability" (*The Origin of Species*, chap. vii. p. 313).

That is, change is passive in character, variability is "indefinite and fluctuating" (*Animals and Plants*, vol. ii. p. 345). "Changed conditions induce an almost indefinite amount of fluctuating variability by which the whole organisation is rendered in some degree plastic" (*The Descent of Man*, part 1, chap. ii.). In short, the internal changes of plants and animals are quite a secondary detail to external forces:—

> "Variability sinks to a quite subordinate position in importance in comparison with selection, in the same manner as the shape of each fragment used by an architect is unimportant in comparison with his skill" (*Animals and Plants*, vol. ii. p. 236).

In the tense rendering of one of Darwin's disciples, Goldschmidt of Munich, Variability is a consequence of external factors.

Thus do Darwin and his island and continental followers admit the quality of change in plants, animals, and man, but the change never springs from within, ever from without. The change is passive, never active.

Some Experiments on Plants and Animals.

And experiments made on plants and animals appear at first sight to support Charles Darwin's contention.

Mechanical Experiment.—Ray sowed a mould in two vessels, one of which was kept moving rapidly for two months, and the supporting tissues of the moving mould underwent marked strengthening and entanglement.

Mathews shook the eggs of starfish gently, and they developed into starfish without having been fertilised. Bataillon showed that

the unfertilised egg even of the frog can be made to develop into a tadpole simply by puncturing it.

Gravity and Centrifugal Experiments.—Gravity asserts a marked influence in determining the direction of growth of a plant. The fir tree strikes upwards like a needle from the ground, and if the developing central shoot be cut away or destroyed, one of the side branches deflects upwards and compensates for the mutilation by itself becoming the top; the roots grow down. The Englishman Andrew Knight experimented in 1809 with centrifugal force. He

Fig. 70.—Virgin-birth in frog resulting from simple puncture of the egg, and without the usual process of fertilisation.

let seeds germinate on a revolving vertical wheel; he found the primary roots grew rapidly outwards on the wheel, the primary shoots striking in the opposite direction. "I conceive myself to have proved," he said, "that the little roots are made to descend and the little shoots to ascend by some external cause, and not by any power inherent in vegetable life."

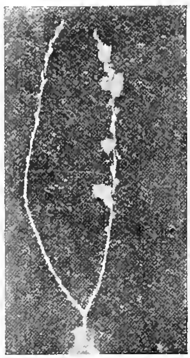
Heat and Cold Experiment.—But one example. The two butterflies, styled *Vanessa levana* and *Vanessa prorsa*, were formerly regarded as distinct species. The wings of the former are marked yellow and black, while those of the latter are black with a broad white band. They are now known to be just the winter and summer forms of one and the same species. The levana issues in the spring and produces the adult prorsa forms the same summer, which then breed chrysalids to emerge again as levana the next

spring. Dorfmeister, by applying warmth to the pupæ, succeeded in producing the summer forms out of the offspring of the summer forms; while August Weismann, by applying cold to the pupæ,

(*After Claus Grobben and Oscar Hertwig.*)

FIG. 71.—The copper butterfly.

The butterflies *Vanessa levana* (A) and *Vanessa prorsa* (B).
A. The winter form. B. The summer form.



(*The Illustrated London News.*)

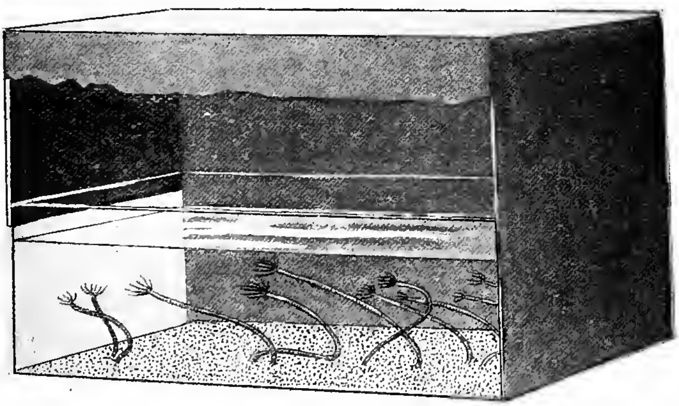
FIG. 72.—A forked plant, of which the right branch was bathed in warm water.

succeeded in producing winter forms out of the offspring of the winter forms.

Light Experiment.—A potato grown in a cellar will turn towards a hole through which light trickles ("heliotropism" or "sun-seeking"). Clayton allowed six bean plants to grow in a spot where they could catch all the sunshine, whilst six other similar plants were covered from the sun by a boarding; when freshly gathered in October the weight of the beans and pods of the exposed plants was to that of the protected as 99 : 29, whilst

(Photo by Margaret Pirie, Edinburgh.)

FIG. 73.—Mustard and cress seedlings, making from the wall (left) towards the window (right).



(Redrawn after Jacques Loeb.)

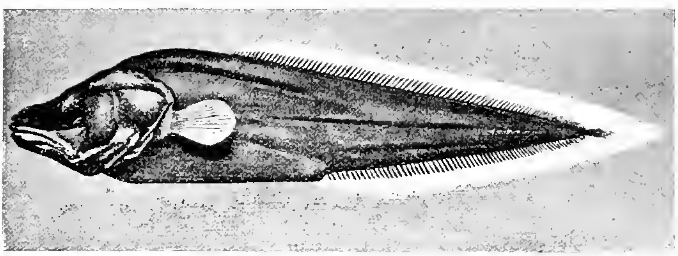
FIG. 74.—Marine worms in a darkened aquarium seeking the light.

the weight of the dry leaves was as 16 : 5. If this experiment be correct, it would be of high interest to the growing of children. Any lady with leisure and a garden would help by testing this

(Photo by S. Fingland, Glasgow.)

Fig. 75.—Light action.

Tulips shielded from light by brown paper bag, on the left, paler and lankier than those on the unshaded side on the right. The lit tulips show green.

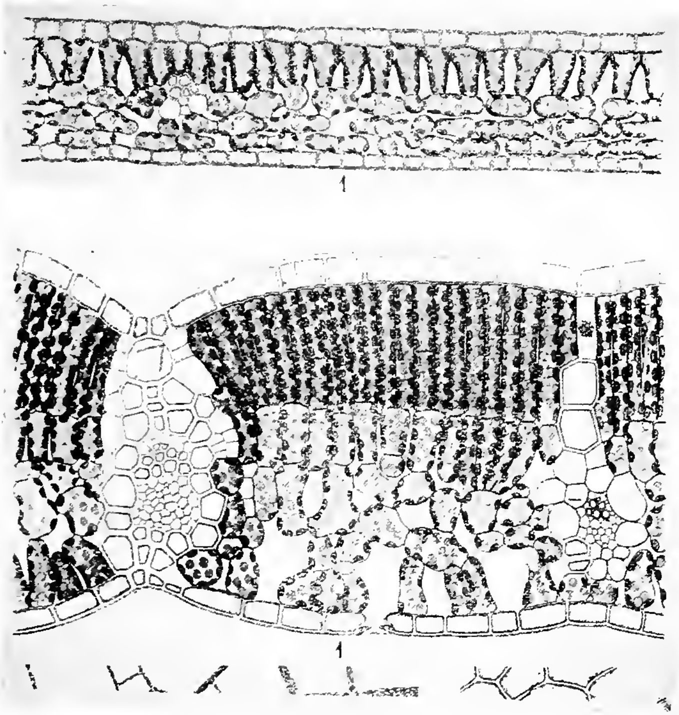


(After C. H. Eigenmann.)

Fig. 76.—Light and tissue. The blind cave-fish of Cuba.

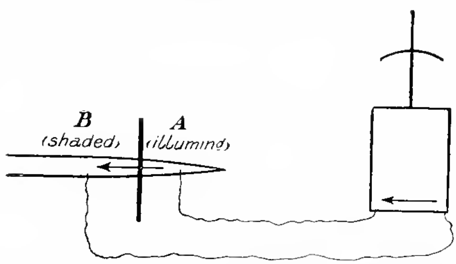
again. Stahl observed that those leaves of the beech tree exposed to the sun are distinctly thicker than the shaded ones. Again, A. D. Waller showed that when light falls on the leaves of plants an electric action passes from the lit to the shaded point. Nägeli filled a three-foot glass tube with water and green spores.

He excluded the light from the upper end of the tube by means of



(*By the courtesy of F. O. Bower, University of Glasgow.*)

FIGS. 77 and 78.—Two beech leaves in microscopic section.
1. In shade. 2. In sun.



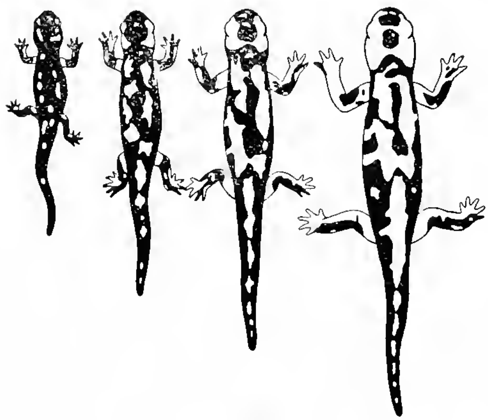
(*After A. D. Waller, "Proceedings of the Royal Society."*)

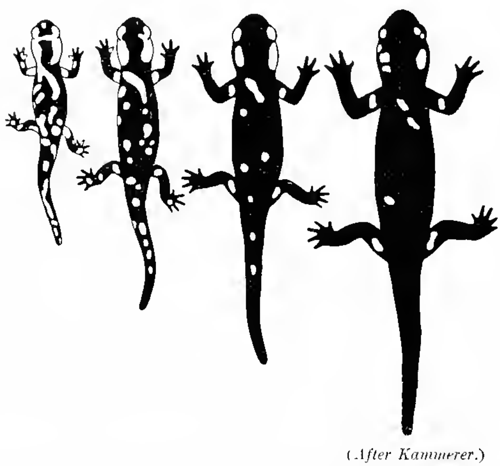
FIG. 79.—Electric circulation in a leaf ; from lit side to dark side.

black paper, and in a few hours the proteeted part of the tube was colourless, the minute organisms having all collected at the lower

(After D. S. Jordan and V. L. Kellogg.)

FIG. 80.—The bee (*a*) drone, or male; (*b*) worker, or female; (*c*) queen, or fertile female.

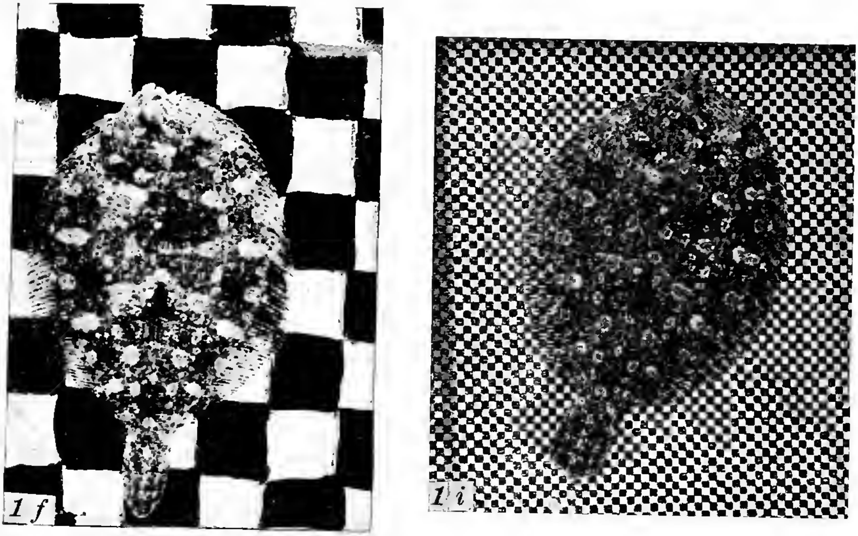




(After Kammerer.)

FIGS. 81 and 82.—Growth of salamanders.
1st series—kept on yellow background. 2nd series—kept on black background.

end; then on the obscuring of the lower end they ascended upwards again. The organisms were not influenced to move by red or yellow light, but by blue and violet light. Bees also seek the light. Kellogg suddenly removed the top of a box covering bees about to swarm, so that the light now entered from above; the bees crept up within the box, and did not make the nuptial flight. The common frog is dark in a shady spot, but if kept for an hour upon white flagstones it looks through its eyes and changes to dusky yellow; compare also



(After F. B. Sumner.)

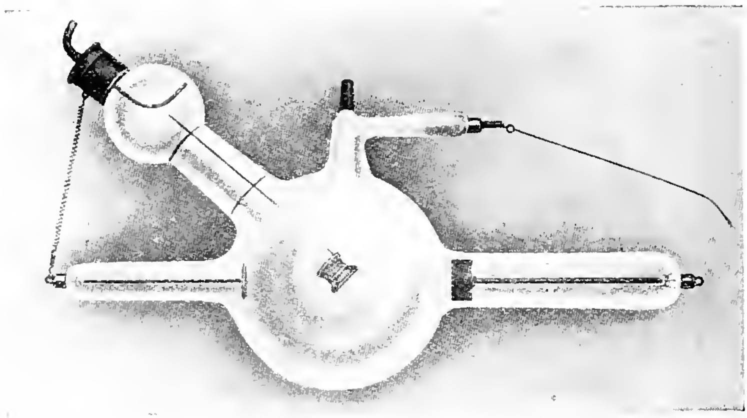
FIGS. 83 and 84.—Flatfish kept in aquarium upon checkered background, and suiting themselves thereto.

1 *f*. On 2-centimetre squares, after 4 days.
1 *i*. On 2-millimetre squares, after 1 day.

Kammerer's plates of the yellow salamander (figs. 81 and 82). The American F. B. Sumner found flatfish can even bring out complicated patterns on their skin, the black-and-white chessboard squares forming the bottom of the aquarium. In man, it is the general belief that he attains full physical and moral stature only in sunlight. This is sought in the modern treatment of disease, and in districts where the sun can be safely played upon the body during the winter, as in the warm valleys of the Swiss Alps, diseased and tuberculous little children are gradually acclimatised to it till finally

they work practically naked in the fields, waxing fat and sturdy on the milk of the farms.*

And considering man in the mass, the main waves of human transmigration, Celt then Teuton then Slav, carrying custom and language from the East to Europe and thence on to people the new worlds, have rolled westward after the sun—sun-seeking upon a vast scale.



(*After G. W. C. Kaye.*)

Fig. 85.—X-ray bulb.

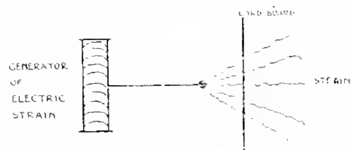
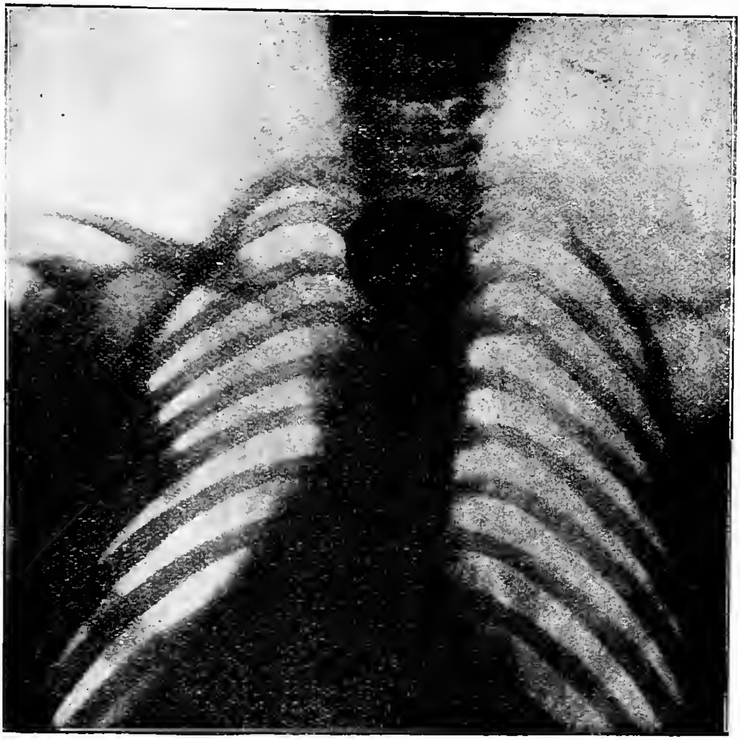


Fig. 86.—The passage of action through matter.

X-Ray Experiments.—Tissues also change when acted on by the Roentgen or X-rays, obtained by sending an electric discharge through a glass tube from which the air has previously been pumped. The discharge passes from a platinum disc to a lead disc, and an action passes out through the glass of the tube to surrounding things—penetrating flesh easily, but being stopped and shadowed by bone, so that the framework inside our body can thereby be seen in

* The digging of a Channel tunnel will bring Switzerland within easy reach of England, and the renting of hospital farms there by the British Government is a step worthy of consideration.

the photograph. The early workers did not quite realise the intensity of the X-rays, and to-day there are men without their hands and arms, which took on, under the X-rays, a malignant or cancerous change, which process may be justly called the experimental production of cancer in man. Nowadays the X-ray workers protect

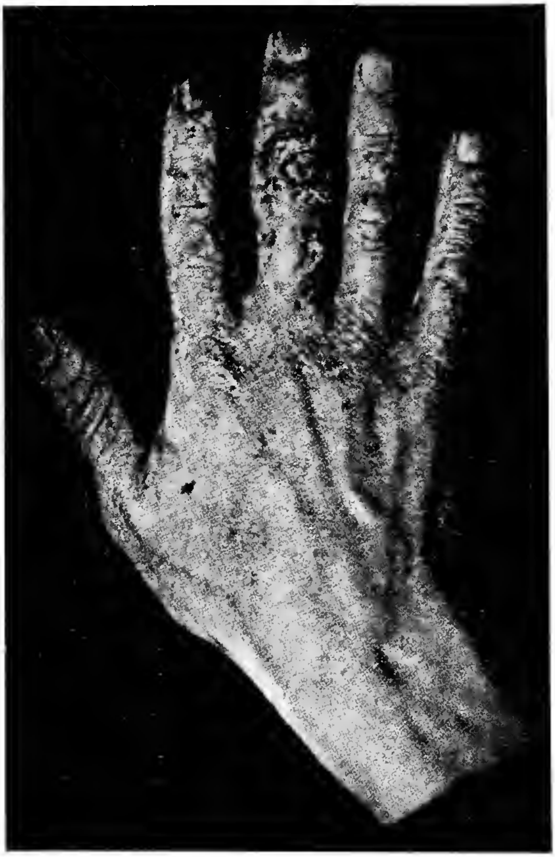


(By permission of Dr. J. M'Gregor Robertson, Glasgow.)

Fig. 87.—X-ray of heart and chest.

themselves against such possible injury by wearing lead aprons and gloves. Contrariwise, the rays can be used for retarding the growth of tissue; thus they have been used for stopping cancer, and C. R. Bardeen found they prevent worms regenerating lost parts. So sometimes the X-rays provoke a cancer, sometimes they retard its development.

Radium Experiment.—Treat the growing embryos of the frog to radium and they tend to develop less rapidly than normal. Similarly in man, cancer growth of the skin can be stopped and even banished



(*After Mackarell and Otto Hesse.*)

Fig. 88.—Cancer of the hand following on chronic irritation by the X-rays.

Fig. 89.—A radium tadpole and a normal tadpole.

The first tadpole had been acted on for twelve hours in an early stage of its growth with radium.

under the action of radium. But radium may, on the other hand, produce ulcers, as Becquerel found in 1896; for some months he had

(*After Louis Wickham and Paul Degrais.*)

Figs. 90 and 91.—Great blood-tumour in a child, before and after stimulation by radium.

been carrying in his waistcoat pocket a lump of the mineral called "pitch-blende," and an ulcer appeared on his skin opposite.

Chemical Experiment.—Plants grown free of iron salts are said to develop their leaves white, but they turn green after forty-eight hours' treatment with traces of an iron solution.

Jacques Loeb has experimented very thoroughly on the action of chemical salts upon growing tissues. He succeeded in getting the eggs of sea-urchins, starfish, and other forms to develop without the usual fertilising process by the male element, simply by adding solutions of magnesium salts to the water ("virgin birth").*

Fig. 92.—Rickets.

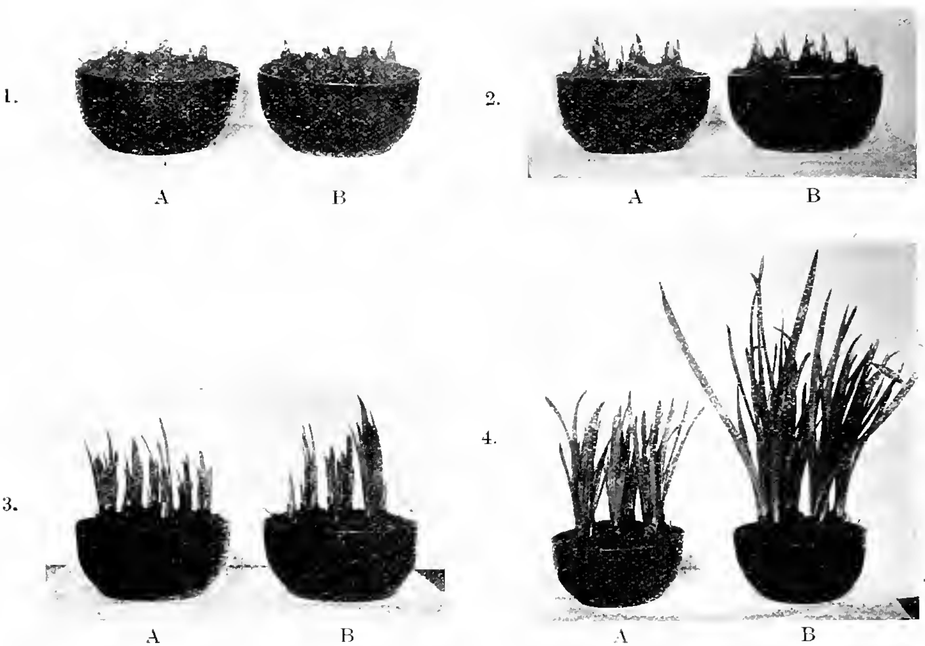
Common salt, salt of potash, and salt of calcium are each and all thought to be essential to animal life. Even a partial deprivation makes a difference, and in cities with a soft drinking water, deficient in

* Delage obtained a similar result by heating and by electric action.

salts of calcium, rickety softening and bendings of bones, such as knock-knee, are commonly observed.

But an excess of salts is also hurtful. Feed a plant richly on common salt, and it dies.

Then alcohol? What change does alcohol lead to in man. A real inquiry into the action of alcohol on man, to be valid, must be



(*Photos by S. Fingland, Glasgow.*)

FIGS. 93, 94, 95, and 96.—Water and weak alcohol (whisky) upon growth of daffodil bulbs set in similar earth and otherwise similar conditions.

A. Supplied every two or three days with a solution composed of 50 parts water to 1 part "Johnnie Walker Red Label Whisky."
B. Supplied with equal amounts of water.

1. 28th December 1913. 2. 28th January 1914. 3. 28th February 1914. 4. 28th March 1914.

an inquisition into the health and housing of every individual, of every stock, over several generations, with full weights and stature measurements. Which is impracticable. All that one can do is to experiment on plant and animal tissue, and thence infer the probable result of alcohol upon the population at large. As in these two bowls of daffodil bulbs, both fed with the same earth, the one

watered with water, and the other with water and a teaspoonful of whisky to the glass.

An experiment in feeding one group of white mice with water and a second group with a mixture of water and whisky, one teaspoonful of whisky to the glass, was made, and goes to illustrate how a first experiment may be inconclusive owing to considerations not anticipated.

(*Photo by S. Fingland, Glasgow.*)

Fig. 97.—Roots of the daffodil bulbs in figs. 93 to 96.
The whisky roots separated easily ; the water ones were closely interwoven.

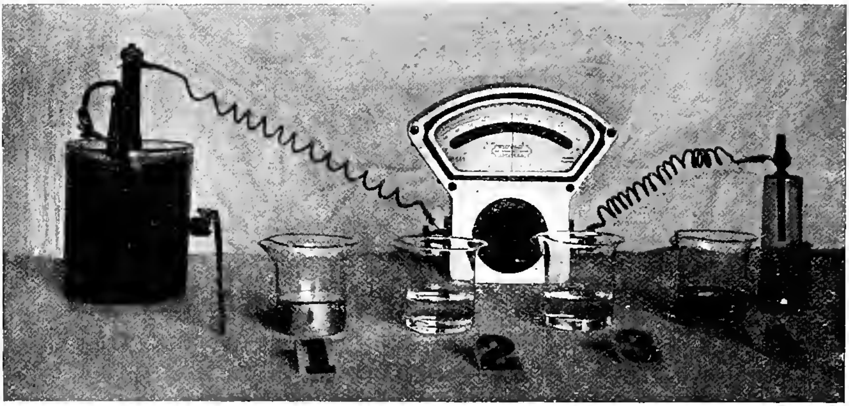
The experiment was conducted by Mr Andrew Wilson, naturalist, of Glasgow. Seventy-two mice were taken and split into two groups of 36 :—

Whisky Side.		*Water Side.*	
26 females	$18\frac{1}{2}$ oz.	26 females	$18\frac{1}{2}$ oz.
10 males	$7\frac{1}{2}$ oz.	10 males	$7\frac{1}{2}$ oz.
Total weight	26 oz.	Total weight	26 oz.

They were all kept in a large glass case with a division across the centre, each side measuring 2 feet 9 inches long, 3 feet 3 inches broad,

and 9 inches deep. There was no possible chance of the two lots being mixed, as the division was covered with tin. The whisky used was "Johnnie Walker," and the strength given was 1·50, or a teaspoonful to the glass.

On 18th February 1915 the experiment was started.



(*Photo by T. J. Walls, Edinburgh.*)

Fig. 98.—Simple test of differences of electric action in fluids.
1. Mercury. 2. Copper sulphate. 3. Water. 4. Alcohol (yellow).

On 2nd April 1915 the condition was thus :—

Whisky Side.	*Water Side.*
4 mice had died.	1 mouse had died.
30 young mice were born.	35 young mice were born—all died.
22 died, 8 were reared.	1 mouse (a female) showed signs of skin disease.
7 mice (all males) showed signs of skin disease.	The 35 mice weighed 32 oz.
The 40 mice weighed 30 oz.	

On 5th May 1915 :—

Whisky Side.	*Water Side.*
5 more mice had died.	2 more mice had died.
35 mice weighed 27 oz.	33 mice weighed $32\frac{1}{2}$ oz.

On 16th June 1915 :—

Whisky Side.	*Water Side.*
8 more mice had died.	3 more mice had died.
27 mice weighed 23 oz.	30 mice weighed 29 oz.
At start :—36 mice weighed 26 oz.	36 mice weighed 26 oz.
On 16th June :—27 mice weighed 23 oz.	30 mice weighed 29 oz.
Loss in weight 3 oz.	Gain in weight 3 oz.

The result is inconclusive, for mice have a vicious habit of eating their young ; to preserve them we would require to isolate the young with their young from the earliest. As Mr Wilson remarks in his statement : "Whenever one mouse has young on either side of the cage, the others kill and eat them."

Several proprietors of public-houses in the neighbourhood became quite interested in the experiment, and used to visit the animals frequently.

Whisky resists electric action more than does water. And

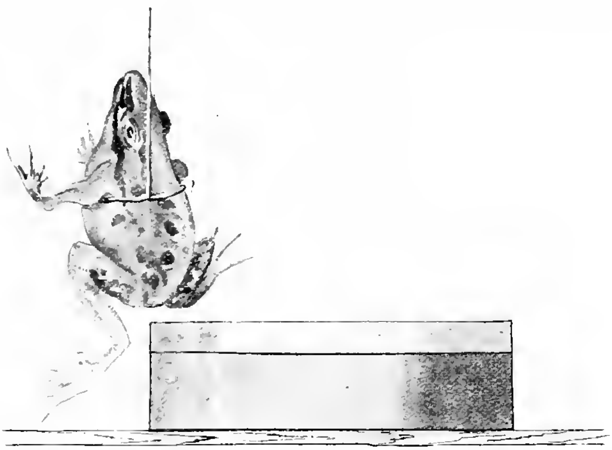


FIG. 99.—Sensitiveness of frog to a solution of sulphuric acid.

whisky does not run so far up the sides of the glass as does water : its surface tension is not the same as that of water.

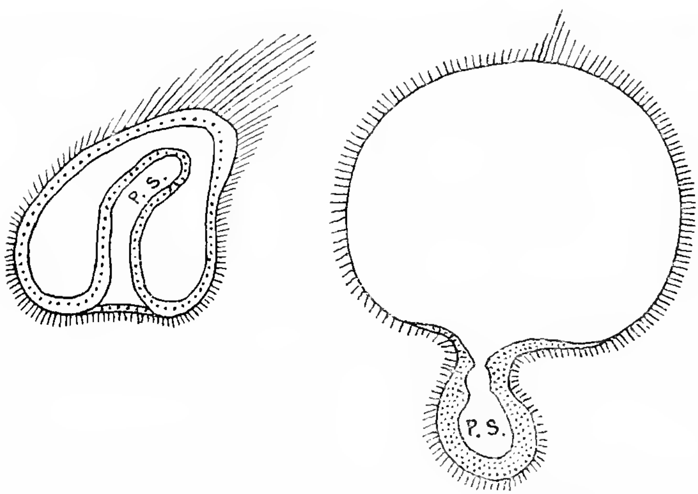
Many experiments, by Poulton and others, have been made on birds and animals with artificial foodstuffs, and the resulting changes noted.

Environment Experiment.—Change of environment represents a mixture of chemical action—light, heat, and other changes. Vegetables grown close to an exposed sea-shore are thicker and more stunted than those grown inland. Nägeli transplanted Alpine plants into the botanical garden at Munich. They altered greatly in appearance, but reassumed their previous character on their return.

And this same capacity to change in response to environment difference is seen also in animals. The peppered-moth used to be altogether a light-coloured variety, but about 1848–50 a striking

black variety made its appearance near Manchester; it was afterwards noticed at many places in the North of England, and subse-

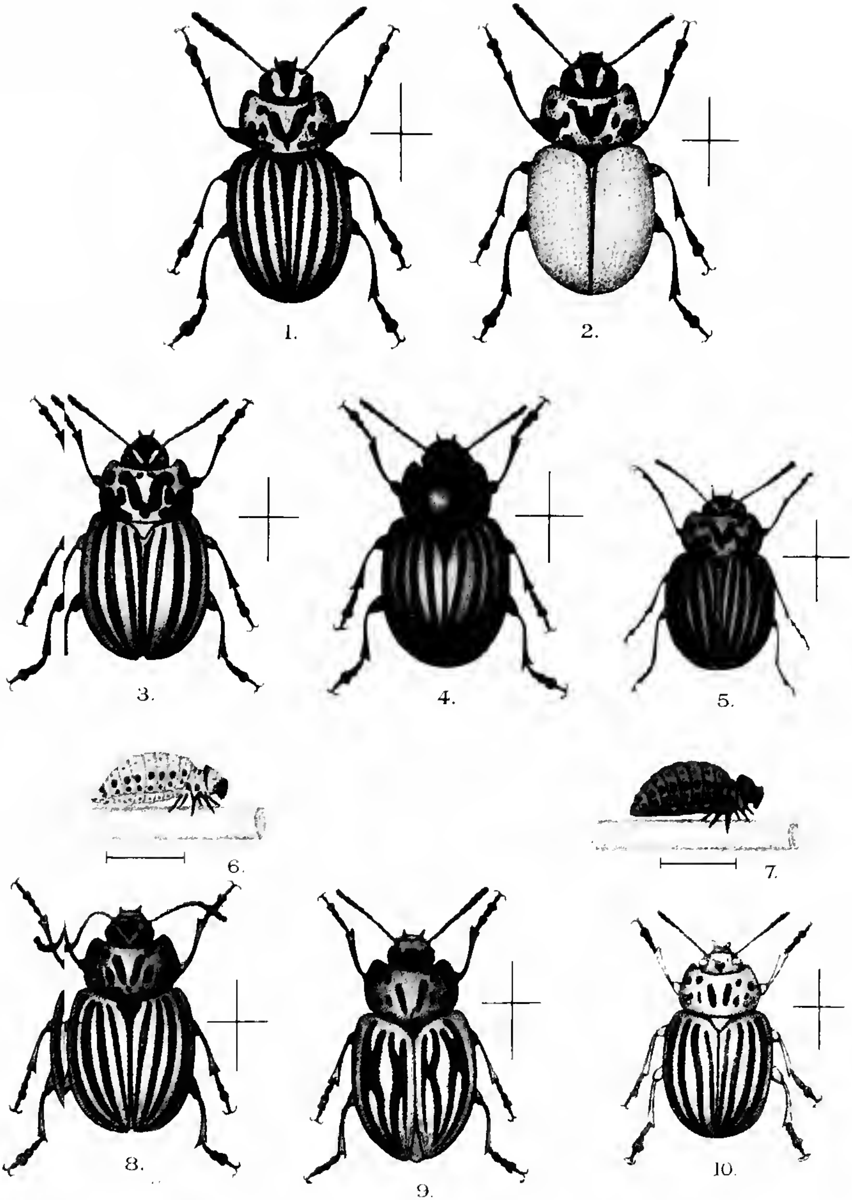
Fig. 100.—Chemical stimulus of potash on growth of mangolds.



(After Herbst and Driesch.)

Fig. 101.—Chemical excitement of a simple organism with salts of lithia. The animal turns its stomach inside out and carries on, to all appearances, cheerfully.

quently in Belgium and Germany; since then the black form has increased in numbers, possibly in relation to the industry darkening the countrysides, for it prevails in Lancashire, Cheshire, and the



After W. L. Tower.

American potato-bug or Colorado beetle.

1 and 2. *Leptinotarsa undecimlineata* and its extreme form.
3, 4, and 5. *Leptinotarsa multitæniata* and two of its extreme forms.
6 and 7. Larvæ of 3 and 5.
8, 9, and 10. *Leptinotarsa decimlineata* and two of its modified forms.

(*After H. T. Brown and F. Escombe in the "Proceedings of the Royal Society."*)

Figs. 102 and 103.—Opposite result from subjecting plants to coal gas.

1. Nightshade—after experiment for 28 days.
2. Fuchsia—after experiment for 54 days.

Left.—In both cases grown in open air.
Right.—In both cases grown in air containing 11·4 parts of carbonic acid gas per 10,000.

West Riding of Yorkshire and Monmouth; thus the black variety was unknown in Huddersfield till between **1860–70**, but now has supplanted the light form entirely (Walter Bateson).

Experiment upon animals shows the same. Young oysters taken from the shores of England and placed in the Mediterranean alter their manner of growth, and form prominent diverging rays like those on the shells of the proper Mediterranean oyster. The American W. L. Tower secured both dark and albino varieties of the Colorado potato-beetle by altering the degree of moisture in the surrounding atmosphere.

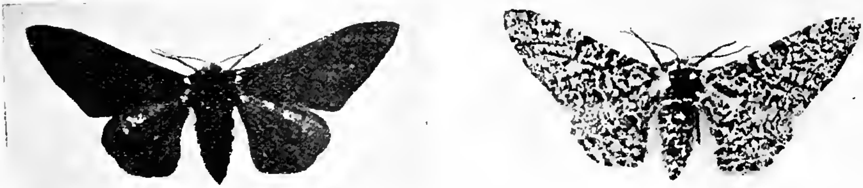
(*After Daniel Berthelot of Paris* (*The Illustrated London News*).)

FIG. 104.—Hastening of development of French beans following upon electric action.

Forbes observed that the Quechua Indians of the high plateaus of the Andes show a striking development of lungs and thorax as a result of living constantly at high altitudes. Rheumatic disease of the bones is very common in Britain, but is almost entirely absent from those of the ancient Egyptians, a difference probably in association with the damper climate of the north.

Again, the Scotsman who emigrates to Alberta is a Scotsman no longer. After a varying acclimatisation time he approximates to the West Canadian type—ruddy yellow, dry, hard-jawed, keen-eyed, and usually spare. Change of climate may even induce a barren woman to conceive, a change perhaps following some difference in the salts of the drinking waters, old and new.

The difference in tissues from differences in environment can even be measured and stated in figures. Contrast the British and the American shore periwinkle. One hundred specimens were taken



(After Walter Bateson.)

FIG. 105.—The transformation of peppered-moth.
1. Dark variety. 2. Light variety.

from ten American and three British localities, their shells measured, and the average and comparison figures worked out for $\frac{\text{breadth}}{\text{length}}$ of the shell as follows :—

Locality.	Average.	Variety Figures.
1. Tenby, Wales	90·96	2·38
2. Kincardineshire, Scotland . .	87·85	2·34
3. Humber District	90·53	2·30
4. St. Croix River, Maine . . .	91·26	2·70
5. Casco Bay, Maine	92·53	2·67
6. Beverly, Mass.	90·65	2·76
7. Nahant, Mass.	92·19	3·03
8. Plymouth, Mass.	90·09	2·48
9. Seaconnet, R.I.	89·72	2·86
10. Newport, R.I.	89·17	2·62
11. Bristol, R.I. (shingle) . . .	90·77	2·75
12. Bristol, R.I. (sand)	91·07	2·83
13. Warren River, R.I.	92·69	2·95

Whatever the explanation, greater climatic extremes in America or some other reason, the American samples show a wider range of variety than the British, 2·765 as against 2·34, 18·2 per cent. higher. The American sparrow is also said to be more variable than the British.

Now, in all these experiments we see, (1) an external change, (2) an internal change, the external change appearing to push, pull, and mould the plant or animal, as the potter moulds his clay, or as the wind drives the yacht before it.

The Arab is the child of the scorching wind and sand ; the Swiss of the wreathed peaks ; the English seaman springs from the salt spray of the Channel.

The eyes of the European darken in India, but is this not due to the sun ?

In the words of Jacques Loeb, it is obviously in the interest of

(*After Henry Lamond.* " *The Sea Trout.*")

Fig. 106.—Scale of sea trout, 1¼ lb. weight, 14½ inches long, and 3½ years old, caught in Loch Lomond on 4th September 1914.

The circular lines indicate a three winters' residence in fresh water prior to migration to the space, salts, rich food, and different temperature of the sea, where the fish spent three months and then returned.

further scientific progress to connect cause and effect directly whenever our knowledge allows us to do so.

The Twin Ideas, Matter and Force.

Now, how does Western man arrange all these changes in Nature in his mind's eye ? Under two heads, Matter and Force. Consider each of these ideas of his for a little.

Atoms.

The elements, plants, animals, and man are all forms of matter, built up of tiny separate particles. A speck of dust blows into our eye, therefore there are separate particles of dust around us, therefore this particle of dust is itself composed of many little specks. These are too small to be seen, but are named "particles," "atoms," "molecules," "ions," and "electrons." The Greek philosophers Democritus and Epicurus are said to have instituted this belief.

As expressed by the Roman poet Lucretius, "Matter is not indefinitely divisible, but is composed of atoms which represent the last stage of division: these are solid and eternal, unalterable and indestructible, are separate from each other by void, and by their combinations form the matter all around us."

John Dalton (1766–1844), the Manchester schoolmaster, applied this idea to the composition of such gases as oxygen and hydrogen, fancying the gas particles as little atomic balls colliding rapidly with each other, crowding together as the gas is compressed, loosening out as the gas expands in volume.

In 1828 the English botanist Robert Brown (1773–1858) published his article *Microscopical Observation on the Particles contained in the Pollen of Plants, and on the General Existence of Active Molecules in Organic and Inorganic Bodies.* The pollen granules of plants $\frac{1}{4000}$ to $\frac{1}{5000}$ of an inch in length displayed movements in water; the movements were found even in burnt and "dead" tissues, and in such of the metals as he managed to reduce to a fine state of division. These movements are now called Brownian. Zsigmondy and Siedentopf have even watched the movements of particles too tiny to be seen by any microscope, for they reflected the light, and these reflections were visible. "Atoms" and "molecules" are the counters of modern chemistry. They are always thought of as discontinuous; so that, as a modern French writer, Henri Bergson, advances, "of the discontinuous alone does the intellect form a clear idea."

"We are at ease only in the discontinuous, in the immobile, in the dead. The intellect is characterised by a natural inability to comprehend life."

Iron, gold, copper, and the other elements, they are dead, and built of dead particles.

Force.

How do these dead elements move? This brings us to the second belief of Western man, that of force or "energy." Many forms of force have been named: such as gravitational, as when an apple falls to earth; mechanical, in the collision of one truck

(*By permission of Longmans, Green & Co.*)
Fig. 107.—Michael Faraday, philosopher and experimenter.

with another; thermal, as in the heating of water in a boiler; visual, as when the sunlight falls on a cloud; chemical, as when an acid burns away a piece of cloth; electric, as in the lightning; magnetic, as in the pointing of the mariner's compass; and so on. We recognise these different changes in external things by our eyes, ears, and other senses. The eyes receive light, the ears hear sound; each sense is attuned; we do not feel an electric shock when light

falls on the eyes, we do not see flashes when we hear the piano played.

The Unity of Forces.

Yet though Western man labels the changes of Nature as distinct and separate, there is something in common between them. In the words of Michael Faraday (1791–1867), who mastered by original experiment the electrical changes in matter beyond any other of his time :—

> "I have long held an opinion, almost amounting to a conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin ; or, in other words, are so distinctly related and mutually dependent, that they are convertible, as it were, one into another."

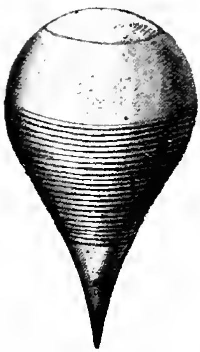


Fig. 108.—Top.

Fig. 109.—Spinning top.

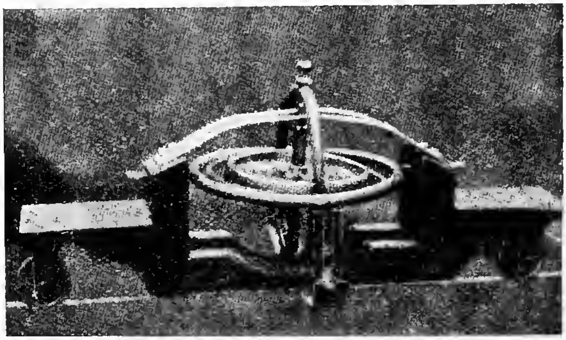
What does he mean ? Well, let us glance at one or two of the many relations of natural action.

Motion and Gravitation.—An apple falls to earth—motion.

The apple falls off down and not up—gravitation.

But these two are related, for a rapidly spinning top does not fall to earth, but stands upright—motion counteracting gravitation. And so we infer a relation between these two actions.

Motion and Magnetic Action.—During the war-inferno a cruiser, the *Lion*, sailed safely into harbour, threading its way through a perilous mine-field, after all its compasses had been shot away, by



(*After V. E. Johnson.*)

FIG. 110.—Gyroscope and model mono-rail.

steering with a gyroscope; for the spinning gyroscope points north and south, independent of the ship.

Motion and Heating.—The hub of a bicycle is hot to the touch after climbing a stiff hill. Conversely, when the water in a kettle is boiled it bubbles—motion related to heating.

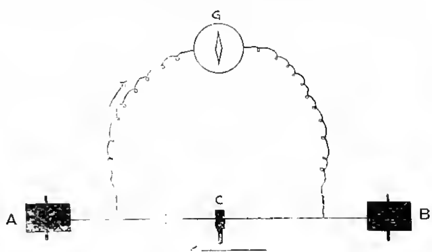


FIG. 111.—Mechanical action and electric action.

A. Struck end. *B.* Resting end. *C.* Clamp. *G.* Galvanometer.

On the wire being struck at X, the galvanometer records a passage of the electric strain, as indicated by the arrows.

Motion and Electrising.—Strike a metal wire at one end, and an electric change passes from the end resting to the end struck.

Conversely, when you repeatedly switch an electric bulb off and on, the bulb may suddenly change into urgent motion and burst into fragments.

In modern hydro-electric establishments the impact of falling

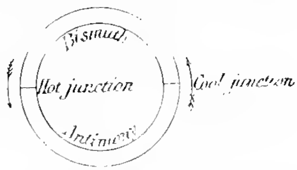
water is used to drive dynamos, and so provide electric light and secure the heating of iron furnaces.

Motion and Lighting.—Half-strike a damp match in the dark, or dip the oar into a still sea on a summer's eve, and the water breaks into sparkling coils and languid flames ("phosphorescence").

Conversely, light change can provoke motion—small wheel models can be driven by means of sunlight alone.

Motion and light action are related.

Heating and Electrising. — Seebeck in 1821 took a ring of the elements bismuth and antimony, heated them at one junction but kept the other cool, and an electric change started to circulate round the ring, as figured.



(*After J. A. Fleming.*)

Fig. 112.—Electric circulation within a bismuth-antimony ring.

What we name "heat" and what we name "electricity" are related.

Heating and Lighting.—In sunlight, heat action and light action

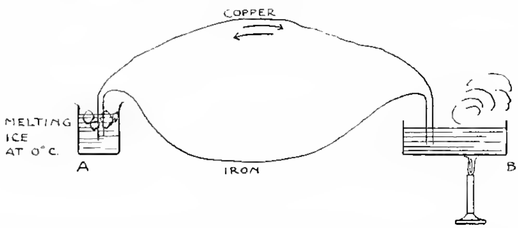


Fig. 113.—Reversal of action in a thermo-electric circuit of two metals, one junction being heated, the other kept in ice. As the junction is heated the action passes in one direction, but on further heating it passes the other way.

come to the earth together. The poker left in the fire glows red, but iron, molten, glows a burning white. The difference in heating has elicited a difference in colour.

There is a closer relation, too, between heating and red light than between heating and blue light; for in 1800 William Herschel placed a thermometer in the successive colours of light (the colours of the rainbow), and found the thermometer read highest towards the red end.

What we call "heat" and what we call "light" are related.

Lighting and Chemical Action.—When light action falls on the silver salts on a photographic plate there comes a picture in silver.

There is a closer relation, too, between blue-violet light and

chemical change than between red light and chemical change: the window in our dark rooms is red, not blue.

Here light action and chemical action are associated.

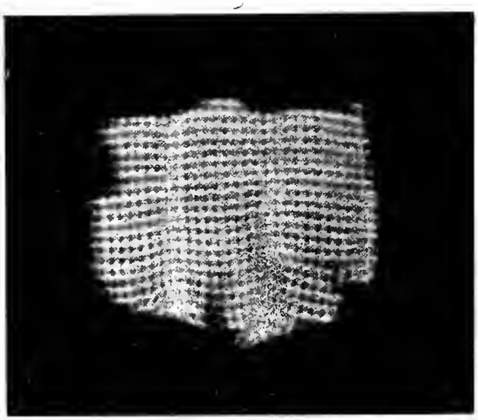


FIG. 114.—A piece of an ordinary incandescent gas-mantle laid on a photographic plate in the dark and photographing itself.

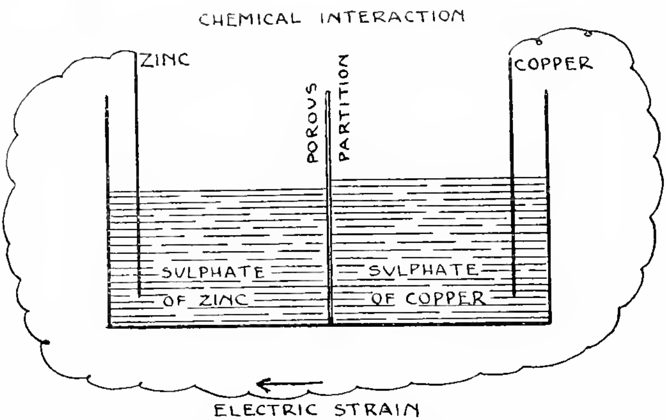
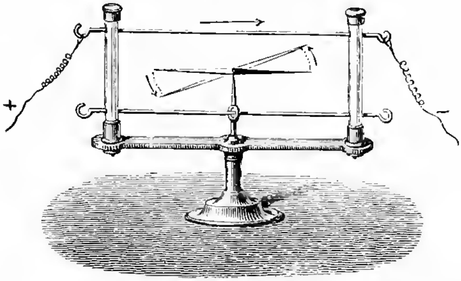


FIG. 115.—Chemical action and electric action. The Daniell cell.

Chemical Action and Radium Action.—Take an ordinary incandescent gas-mantle, which contains the radio-active element thorium; place it on a photographic plate in the dark and press it down with a plate of glass. The mantle then photographs itself in the dark upon the photo plate.

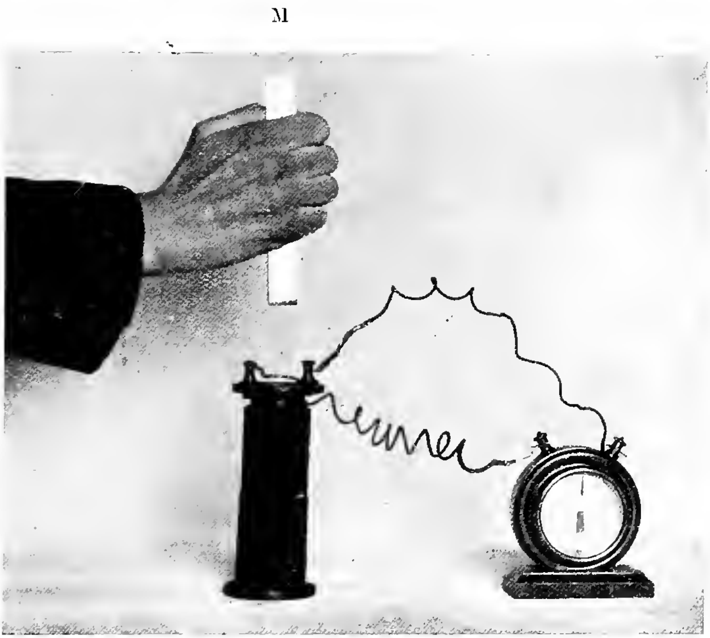
Radium action is related to chemical action.

Chemical Action and Electrising.—In the Daniell electric cell,



(*After Magnus M'Lean of the Technical College, Glasgow.*)

FIG. 116.—To illustrate Oersted's experiment.



(*Photo by T. J. Walls, Edinburgh.*)

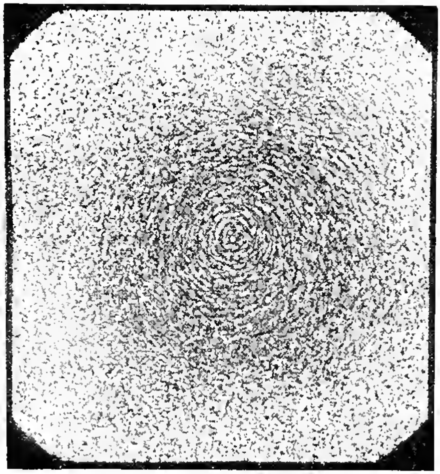
FIG. 117.—Intensifying and extensifying a circuit.

Let a hollow coil of wire be connected with a registering magnetic needle, and a magnet (M) be held over it. Then, as long as the magnet remains stationary no change is indicated in the second circuit. But thrust the magnet into the coil, and the needle is deflected as long as the magnet is moving in; when the magnet stops moving, the needle recovers its original position. On the magnet being withdrawn, the needle swings in an opposite direction.

where zinc acts on copper sulphate to form zinc sulphate, an electric

action begins when the zinc and copper terminals are connected up. As Faraday remarks, "The forces chemical affinity and electricity are one and the same."

Electrising and Magnetising.—The Dane H. C. Oersted found in



(*After J. A. Fleming.*)

Fig. 118.—Electro-magnetic connection.
Steel filings arranged in circular magnetic fields around a No. 12 wire electrically excited.

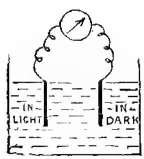


Fig. 119.—Electric circulation from lit metal plate to dark metal plate.

1819 that if the copper wire of his electric battery were placed parallel to a magnetic needle the needle turned at right angles to the wire.

What we term "electricity" and what we term "magnetism" are united twins.

Conversely, Michael Faraday took a coil of wire and thrust into it a permanent steel magnet. An electrical rush through the coil accompanied the insertion of the magnet, another rush in the opposite direction accompanied its withdrawal.

Electro-magnetic Flow and Lighting.—A beam of light action, *e.g.* the light obtained by burning some soda in the flame of a Bunsen

(By permission of the proprietors of the "Encyclopædia Britannica.")

FIG. 120.—One aspect of the Northern light or aurora borealis.

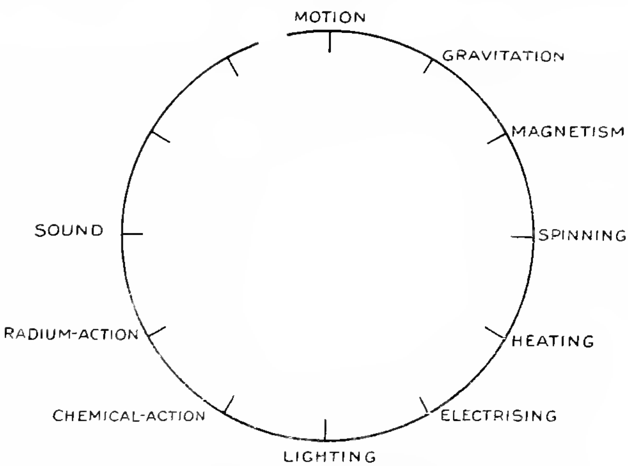


FIG. 121.—The chain of action.

burner, can be brightened and split up when influenced by a strong electro-magnet.

Conversely, if the end plates of an electric circuit be set, one

in the dark the other in the light, there occurs an electric circulation from the lit to the dark end. And some have even gone so far as to suggest that the light of the sun is but the magnetic waves of that body.

Lighting, Magnetising, and Sound.—The Polar or Northern light, the aurora borealis, is associated with deflections of the magnetic needle and with crackling and hissing sounds, facts observed by Arctic explorers and whalers.

Lighting, magnetising, and sound related.

Sound and Motion.—A peal of thunder shakes the house.

Sound and motion related.

Electrising Motion and Gravity.—A powerful electro-magnet induces heavy balls of iron to roll *towards* it. Conversely, as we noticed already, when a disc of aluminium is placed over and acted on by an electro-magnet it rises up into the air *away* from the electro-magnet like a ball on a fountain. It loses weight.

Electrising, motion, and gravity all related.

The Chain of Forces.—We thus have a linked chain of what are called "forces." This chain is inadequate and incomplete, yet it sufficiently indicates how the changes of Nature have something in common.

The Nature of Force.

That something is at present unknown. But it is usually described in the general word Force or Energy. Every piece of matter contains two things: firstly, so much dead material; secondly, so much pent-up force.

When outside force acts on matter the matter may change, but it cannot change of itself; or, as stated in the first law of Isaac Newton: "Every body perseveres in its state of rest or of uniform motion in a right line unless it is compelled to change that state by forces impressed thereon."

The outside force is called the *cause*, the ensuing change in the matter is called the *effect*. If the outside force acts by exploding the internal pent-up force to work, then one speaks of a first cause and a second cause and an effect. But the internal force or second cause is held to be in essence distinct from the matter with which it cohabits.

Instance that far-reaching discovery of modern science, the propulsion of a bullet from a rifle. The hammer falls on the cartridge, a chemical change occurs in the powder, and the bullet

issues on its mission. The leaders of Western knowledge tell us a certain amount of mechanical "force" or "energy" has passed from the hammer to the cartridge, exploding another fixed and definite amount of chemical "energy" lying fallow in the powder. The bullet then obtains the force of movement, and expends this when it strikes the bone and brain of the man it is intended to strike.

Has this thing, Force, ever been isolated and seen? No, it has never been actually seen, but it was imagined after this fashion. While the American Rumford was engaged superintending the boring of cannon at Munich towards the end of the eighteenth century he was struck by the heat change arising from the boring of the brass castings. He immersed the borer and the castings to be rotated in 88·77 lb. of water (at a temperature equal to 60° F.), contained in an oak box, and found that after two horses had turned the castings for 2½ hours the water boiled. Rumford did not commit himself to any theory of "energy." He simply concluded that "anything which any isolated body or system of bodies can continue to furnish without limitation cannot possibly be a material substance." It was a spirit within things.

The famous experiment of Humphry Davy (1778–1829) followed in 1798. He procured two pieces of ice "of a temperature of 29°, six inches long, two wide, and two-thirds of an inch thick: they were fastened by wires to two bars of iron." Their surfaces were placed in contact, and by means of clockwork were "kept in a continued and violent friction for some minutes": the rubbing was done by clockwork so as to preclude the possibility of any heat passing to the ice from the hands. The two opposed surfaces "were almost entirely converted into water, which water was collected, and its temperature ascertained to be 35° after remaining in an atmosphere of a lower temperature for some minutes. The fusion took place only at the places of contact of the two pieces of ice, and no bodies were in friction but ice." Davy thus succeeded in converting ice into water, though itself at a temperature below the freezing point. This experiment was a fundamental one, for nothing material had been added or taken away from the ice.

The conclusion drawn from the experiments of Rumford and Davy was thus: If heat be not a substance, it must surely be an "energy" or "force."

The next step in this inquiry was made on the Continent, especially by the Frenchman Sadi N. L. Carnot (1796–1832) and the German

Fig. 122.—Humphry Davy, English chemist.

Discoverer of the elements sodium, potassium, calcium, barium, and strontium; the recommender of chemicals for pain; the inventor of the miner's safety-lamp.

Fig. 123.—Humphry Davy's experiment of rubbing ice upon ice at a temperature below freezing point.

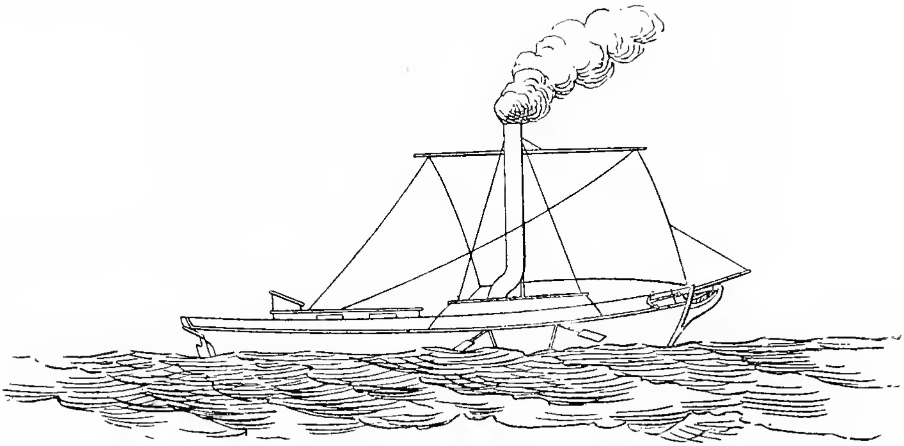
Hermann von Helmholtz (1821–1894).* They made this assumption, Force (Energy) is a thing definitely limited in amount. In the explosion of a gas-engine, for instance, a certain amount of heat and chemical force changes into an equal amount of mechanical force, which then does a certain amount of work in driving the piston. And the motion of the locomotive and ship is the exact equal in quantity of the force stored up in the burning coal. The Niagara Fall and the Victoria Falls of the Zambesi are slightly warmer at the

Fig. 124.—Henry Bell, Scottish engineer and shipbuilder.

foot than at the top—a quantity of the motion-force has changed into heat-force.

Joule.—To measure Force, James Prescott Joule (1818–1889), a brewer of Salford by Manchester, carried out a series of experi-

* Henry Bell, the sailer of the first steamboat; George Stephenson, the railroad engineer; Michael Faraday, with the induction coil; Hermann von Helmholtz, who first saw the back of the living human eye with his "ophthalmoscope"; Morton of Boston and James Young Simpson, of chloroform fame; Louis Pasteur, who isolated the minute bacteria; Joseph Lister, the applier of carbolic acid as an antiseptic to infected wounds; Kelvin, of the compass and ocean cable; Bell, of the telephone; Thomas Edison, of the phonograph and cinema; and Henry George, the realiser of the value of land, were among the chief originators of the nineteenth century.



(*After a facsimile of the original draft by John Wood.*)

Fig. 125.—The *Comet*, built at Port-Glasgow in 1811.

(*Photo by John Moffat, Edinburgh.*)

Fig. 126.—James Young Simpson, discoverer of the use of chloroform.

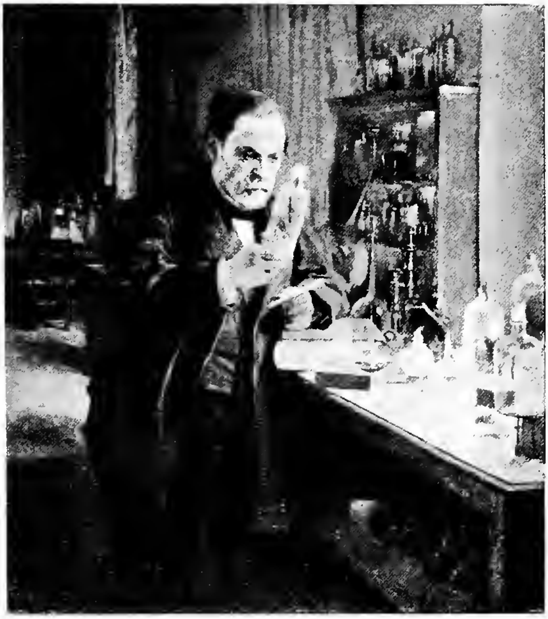


FIG. 127.—Louis Pasteur in his laboratory.

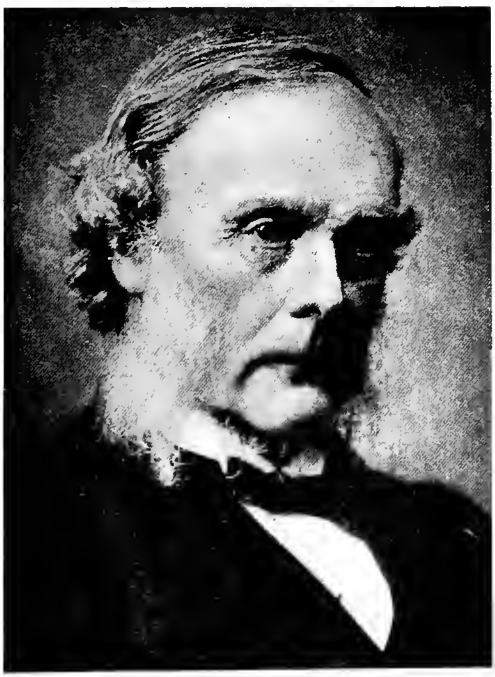


FIG. 128.—Joseph Lister.

ments and calculations extending over twenty-five years. He churned up water with brass paddles worked by means of weights, and when the water warmed in churning he measured the resulting rise in the temperature of the water; he thus obtained two facts: (1) the amount of work performed in foot-lbs.; and (2) the rise in the temperature of the churned water. And after years of experiments he calculated it took 772 foot-lbs. of work to raise 1 lb. of

(*From a photo lent by the Canadian Pacific Railway.*)

FIG. 129.—The Canadian or Horseshoe Fall at Niagara.

water through 1 degree Fahrenheit. A measuring unit of heat was then taken for convenience, the "Calory," and in the words of the German chemist Wilhelm Ostwald: "If the amount of heat required to melt 1 gramme of ice be measured, it is found to be 80 calories."

Both in popular and expert works on science one can read frequently of *quantities* of "heat." Thus the latest edition of the *Encyclopædia Britannica* runs as follows:—

> "The quantity of heat contained in a body obviously depends on the size of the body considered. Thus a large kettle full of boiling water will evidently contain more heat than a teacupful, though both may be at the same temperature."

In this fashion does the scientist of the West weigh out his "force" or "energy," just as the grocer weighs out his butter in pounds avoirdupois. When the radio-active substances radium, polonium, thorium, ionium were discovered, they were at first esteemed exceptions to such an exactitude. They were

(*From a photo lent by the British South Africa Co.*)

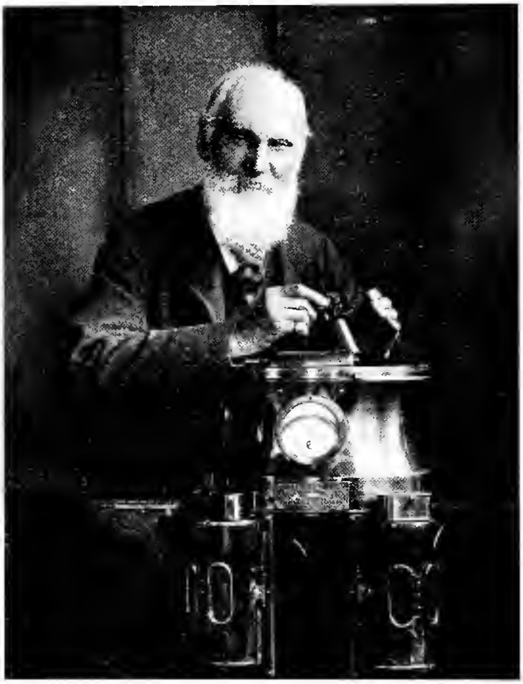
FIG. 130.—"Musi-oa-tunya," on the Zambesi Piver; named the Victoria Falls by David Livingstone.

regarded as widow's cruses of boundless energy. But their energy is now reckoned in definite "periods of decay," the period for radium being given by Ernest Rutherford of Montreal as 1750 years.

To sum this up briefly, "force" or "energy" is an invisible spirit which can be measured in amount and takes on many forms—mechanical, heating, chemical, electrical—but ever one in quantity. It is as when a banker can pay you £5—in notes, gold, silver, or copper. This view is what is called the Conservation of Force or Energy.

In the more precise language of James Clerk Maxwell (1831–1879) :—

> "The total energy of any body or system of bodies is a quantity which can neither be increased nor diminished by any mutual action of these bodies, though it may be transformed into any one of the forms of which energy is susceptible."



(*Photo by T. & R. Annan, Glasgow.*)

FIG. 131.—Kelvin.

The Conservation of Force or Energy leads on to another Western belief, the Dissipation of Force or Energy. Sadi Carnot remarked you cannot get work out of water unless it be falling from a higher level to a lower. The Scotsman William Thomson (Lord Kelvin) (1824–1907), the electrical engineer, also realised that while it was easy to convert the work, say, of a locomotive into heat, it was not possible by any known method to convert all the heat back again into work. So he drew a distinction between "available energy" and "diffuse energy," and held the available energy of the Universe

was steadily deteriorating into the useless form of diffuse heat. Thus the Conservation of Energy ended logically in the Dissipation of Energy, an idea dear to the philosophers. "Both Matter and Energy are always unchanged in amount. But, according to the Law of Dissipation of Energy, the time is approaching in which there will be no further transformation of energy out of which work may be obtained" (Arthur Balfour). The sun gives heat to the earth, the grass grows, the man eats the ox, the man dies and gives back some heat.

And, in the words of Herbert Spencer (1820–1903) :—

> "If the solar system is slowly dissipating its forces—if the sun is losing his heat at a rate which will tell in millions of years—if with diminution of the sun's radiations there must go on a diminution in the activity of geologic and meteorologic processes as well as in the quantity of vegetable and animal existence—if man and society are similarly dependent on this supply of force that is gradually coming to an end ; are we not manifestly progressing toward omnipresent death ? The proximate end of all transformations is a state of quiescence."

The Frenchman Janet says as follows :—

> "The world we live in is, in reality, a double world ; or rather, it is composed of two distinct worlds ; one the world of matter, the other the world of energy. Copper, iron, and coal are forms of matter. Mechanical labour and heat are forms of energy."

The Western idea of Force has also been adopted and applied by the press, with its influence and responsibility. Max Harden, one of the leading continental journalists, is able to state : "One principle, and one principle only, counts. It sums up and contains all others—force" (*The Future*, October 1914).

The Outcome of Western Belief.—To sum up these two Western beliefs :—

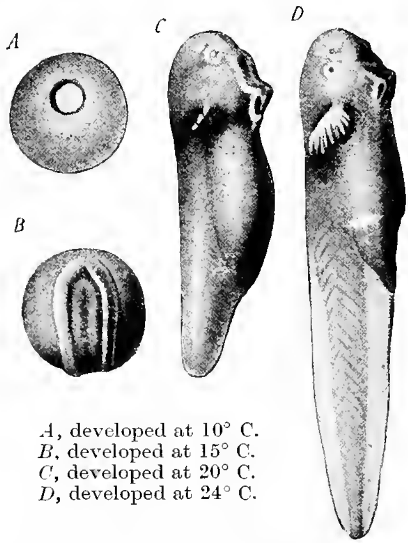
> Matter is a dead thing, built of little dead pieces or atoms.
> Force or Energy is another thing, all by itself.
> Both Matter and Force are limited in amount.

But Force flits, a ghostly body, from one piece of dead matter to another, activating them in turn, as a bee flits from flower to flower, fertilising them as it goes.

Pieces of matter do not change of themselves, but only from without.

Henee the decisive factor in every change is the previous condition of the thing changing: " That which hath been is now; and that which is to be hath already been"; or, in the modern words, " What was found in the effect was already in the cause."

This view is acceptable to many. Thus the German Oscar Hertwig divides the causes leading up to any change in any material



A, developed at 10° C.
B, developed at 15° C.
C, developed at 20° C.
D, developed at 24° C.

(*After Oscar Hertwig.*)

Fig. 132.—Four frog eggs three days after fertilisation.

system into two groups, external and internal. The external causes are the environmental ones of light and warmth, the various meehanical forees, the ehemieal influences of air, water, and earth. The internal eauses are those embedded by birth, by heredity, in the tissues of plants and animals. He illustrates this distinction between causes external and internal as follows :—

> (1) " Take four fertilised eggs of the frog (*Rana fusca*), and let them develop at four different temperatures: the first at $-1°$ C., the second at $+5°$ C., the third at $+15°$ C., and the fourth at $+25°$ C. On comparing the four eggs on the third day of ineubation we find that while the develop-

ment of the first has scarcely started, the development of the fourth has proceeded so far, that the head and tail are now quite distinct."

Hertwig calls the unequal external temperature the efficient cause of the differing results.

(2) "Take two fertilised frogs' eggs and two freshly laid hens' eggs and expose one of each kind to temperatures of 15° C. and 38° C. On examining them after three days we find that at 15° C. the frog's egg is developing well, but the hen's egg remains unchanged; at 38° C. we find that the hen's egg has changed into a little embryo with pulsating heart, but the frog's egg is dead."

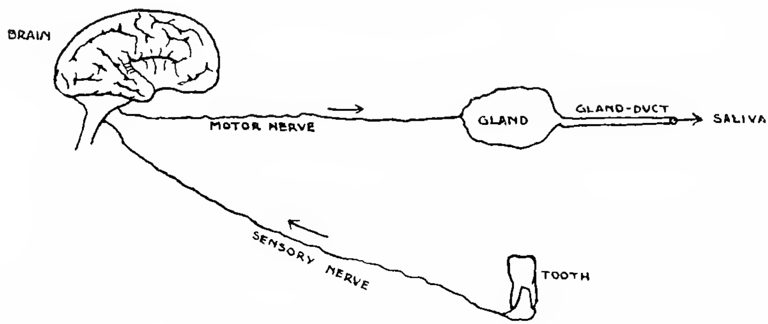


Fig. 133.—Toothache to saliva.

To explain the different behaviour of frog and fowl, Hertwig infers some internal cause at work.

And each internal cause is the result of a definite number of causes, $A+A_1+A_2+A_3+A_4+\text{etc.}+A$, definitely inherited forces, some internal, some external, which have been gradually piled up in the frogs and hens from generation to generation. Each egg reacts in exact obedience to its own or "specific" structure—

$$A+A_1+A_2+A_3+A_4+\text{etc.}+A.$$

Hertwig admits there often appears a wide disproportion between the Cause and the Effect, as when in toothache a slight irritation of a minute nerve occasions a great outpouring of saliva. But this disproportion is, to his mind, only apparent, depending upon a complicated chain of causes in the tissues of the brain and salivary glands. The saliva pouring out is just the last link of the chain;

the other links are there in brain and salivary gland, though we do not see them; the stimulus of the tooth to the nerve lets these underlying causes act, just as Ulysses *caused* a certain storm when he slipped the four Winds from their sacks. The effect *must* follow, or, as he quotes the philosopher Arthur Schopenhauer (1788–1860):—

> "Just as the rolling ball must set the resting one in motion, so the Leyden jar must discharge itself when touched; arsenic must kill everything living; the corn seed which has been kept dry and preserved for thousands of years must germinate, grow and become a plant as soon as it is placed in suitable soil, and exposed to air, light, warmth and moisture. The cause is somewhat complicated, the effect heterogeneous, but the necessity is not a whit less on that account."

On the strength of such reasoning Hertwig feels able to support the Law of Causation or Necessity as advanced by the botanist Nägeli: "The qualities of organisms are the necessary consequence of definite causes."

This sequence of argument carries still further. For as there exists a closed chain or routine of causes and effects in every change, so the causes themselves can be shown to be as much routine and mechanical as are the effects. In the words of Karl Pearson, "all cause is routine." Trace back cause upon cause, and no First Cause will be found to appear. And the world and all upon it becomes a mechanism, with rhyme but without reason, a "how" without a "why," a passive thing, a dead spinning ball.

The Expert informs the Man.

But, may exclaim the average man or woman, surely man is different. The sense of integrity and sin and unity and freedom, the high mathematics of the builder of ships, the colours of the Sistine Madonna, the majesty and music of Shakespeare, the trust of Columbus and Nansen and Scott, the distant aspirations of Buddha, Christ, Mahomet, the thrill of a man against cruelty and fear, the tenderness of a mother for her child: is the faith in all these false? Am I not free to will evil or good? To which comes prompt the answer of the Western expert, in the usage of the Scottish Law Courts: Not proven!

Animals display freewill just as you do. The crow discriminates between the man and the man with a gun; the white rat learns

to escape from its cage by putting its paw under the door, pulling it inwards, bending its head under it, and so emerging; the cat hesitates before it leaps from the bookcase to your shoulder; one of the famous horses of Elberfeld on being asked to calculate

$$(\sqrt{144}+\sqrt{256})$$

gave twenty-eight taps with its hoof; the Airedale terrier Rolf

Fig. 134.—The Sistine Madonna of Raphael.

of Mannheim even assists the children at their lessons, and on being asked by a visitor to calculate $\sqrt{2809}$, gave fifty-three by tapping with its paw.

Sceptical of this, you may write Professor H. E. Ziegler of Stuttgart and Dr Sarasin of Basle, who are courteous in reply to questions. They say that this dog has been visited by scientists from many

parts of Europe and America: how its mistress first noticed its ability when rallying her little child on its stupidity: "Two and two

Fig. 135.—The dog Rolf of Mannheim.

Fig. 136.—Scots terrier, smiling.

make —— ? Why, even Rolf knows that," and Rolf pawed her dress four times; and how she trained it then. Two days after an inspection

by a visitor the dog was tested, and it tapped out a reply in these terms : " Saw many pictures with him and told, what is ; it's enough, don't wish to say more, what is ; stupid ; everybody's bothering me."

The digestive processes of man and animals are not dissimilar. We all know how a dog waters at the mouth on seeing his food. The Russian Ivan Petrovic Pavlov was interested in this to prove the reason. He therefore opened into the stomach of a dog, drew out a sac of it to the front, and watched the flow of its stomach juices. The dog became used to this condition. And when it was presented with the view of its food, it slavered also at the stomach with expectation. Then Pavlov cut the two long nerves which connect the brain with the stomach, and no more juice flowed from the stomach on the dog seeing food, for the nerve pulse from brain to stomach was lacking. Pavlov called this mouth and stomach flow when the dog yearned to eat its " soul-secretion." And facts go to show the possession of similar digestive secretions in man.

" But," you ask the Westerner, " how can the Memory and Will of animals and man be explained ? See, I rise from this table ; I get up and move about. Is this not done of my own accord ? " To which comes the reply : You are not the only animal that remembers. Dogs have been known to return home after being removed many miles by train. The carrier pigeon, never once outside its loft, remembers it even from a great distance, and back it comes safe—from thirty miles and more ; it has a sense of memory beyond even that of man. The elephant has been known to avenge an injury after years of waiting. The social intelligence, too, is evident even in the ant, for should it find something too heavy itself to carry home, it leaves the find, goes to the nest for assistance, and returns with some of its companions.

And the animals exhibit a morality akin to man. The setter alone in a field will start in pursuit of game, but if he sees his master, the memory of previous pain from his last thrashing prevents him ; the motive is there, though you may fail to recognise it.

" But there is Will ! " you say.

Ah ! replies the expert, will is easy to explain. For the brain receives messages by the sensory nerves from the skin, it gives out messages by the motor nerves to the muscles ; if the sensory message runs straight through to the brain on to the motor messages, we have a reflex nervous arc, a closed mechanical circle. You turn round quickly in your chair, and your knee knocks against the sharp edge of the table. Without any thought of what you are doing

your hand moves down and rubs your knee, or the part may cause you so much discomfort that you hop up in a hurry and do a pace round the room. On first examination these two actions appear of totally different character, the first unconscious, the second conscious. But this difference is only apparent, for in both cases there occurs a physical change in the nerve tissue, a message from skin to brain and from brain to muscle; and in both cases your action really proceeds from the brain-memory of past sense-impressions, the immediate sense-impression being conditioned by the physical impresses of the past. When you rubbed your knee without thinking, only a few past experiences came into play; you are said to act involuntarily, from instinct or habit; the sensation may pass over into the motion so quickly, you may be so absorbed in your work, that you never realised the message from the sensory nerve at all; only a spectator, perhaps, has been conscious of the whole process of knee-knocking and rubbing; you can thus receive a sense-impression without recognising it, or a sense-impression does not involve consciousness. On the other hand, when you started up round the room we call it an act of the will, but the "will" is equally determined by the past training and experiences we have undergone; as a child you struck your knee often, and gradually stumbled on the discovery that a hop round the room helped the pain; you hop around now and think it freewill; not at all, you are just recording the earlier stamp upon your brain when a child. Consciousness is no proof of will power. Your brain is an automatic telephone exchange. Your originality is spurious, being but a consciousness of a *finite* number of past sensory impressions. The processes intervening in the brain between immediate sense-impression and conscious exertion are just as much routine changes as what precedes the sense-impression or follows the exertion. In the words of Karl Pearson, "Will, when we analyse it, does not appear as the first cause in the routine of perceptions, but merely as a secondary cause or intermediate link in the chain." Your brain is "a marvellous complex, upon which no element of race, of ancestry, of education or of experience has failed to leave a more or less indelible impress."

Man can but register the past.

Let the poisons of syphilis corrode the finer paths of your brain, and a lot your boasted freewill will help you! Destroy the nerve-bridge in your brain between word-vision and word-sound, and a man may understand language and yet have lost all power to express his thoughts in the spoken word. Destroy other nerve-bridges, and

a man will become a maniac. In the words of Karl Pearson, "Had we knowledge enough we can hardly doubt that all this brain action might be described mechanically" (*Grammar of Science*). Or in the words of Jacques Loeb: "We eat, drink, and reproduce, not because mankind has reached an agreement that this is desirable, but because machine-like we are compelled to do so."

As applied to the problems of modern society, this view of man as a being passive and automatic is of interest. The problem of the slums of some of the great cities, for example. The usual view of the scientist is based on the famous theory of the germ- or reproductive-tissue advanced by the German zoologist August Weismann.

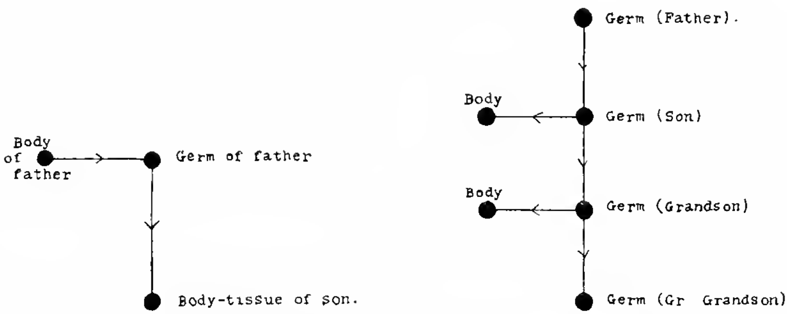


FIG. 137.—Two diagrams contrasting the usual view and Weismann's theory, a germ carrying a corpse.

The average man of us regards his body and his reproductive-tissue—if indeed he ever thinks of the matter at all—as if the body does certain things and the germ-tissue is a kind of memory recording the doings of the body—just as the brain records the feelings of his skin. Weismann challenged this belief, reversed the idea of it, and laid chief weight on the germ itself. The body to him is but an outgrowth from, an excrescence on, the germ. The body supplies the germ with nourishment, but the germ is the essential part, the immortal part; for only those cells which preserve themselves by dividing away and parting from this mortal body deserve to be called immortal. Life is a current passing on from the germ of one generation to the germ of the next generation, our bodies but the leaves borne along on the surface of the stream, doomed to wither and perish.

The spider sits on the middle of the web he has spun. Weismann claims you can injure the web (the body) without affecting the spider

(the germ); the two are quite apart; of course you hurt the spider *indirectly* by tearing its web and depriving it of its food, but there is no immediate union between the web and the spider—still less between the web and the spider's descendants. Changes occurring in the body are not transmitted. How indeed could they be, how could these which are really external influences leave any trace on the semi-fluid germ within?

Mutilations are not inherited. A man may lose his thumb or more, but his son will have one for all that. Horses and dogs have been

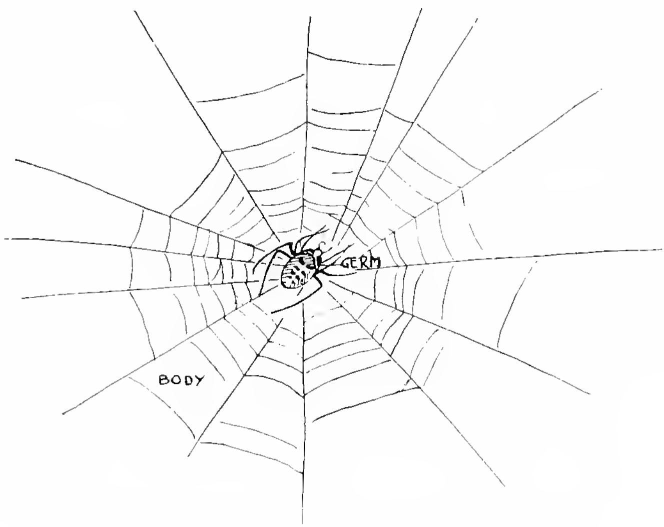
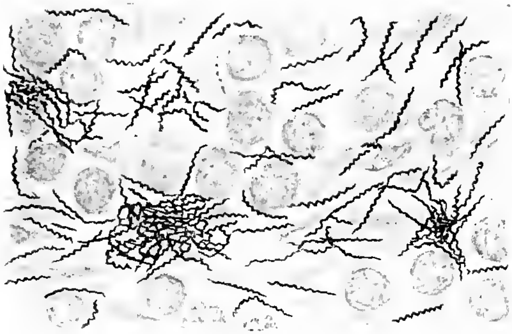
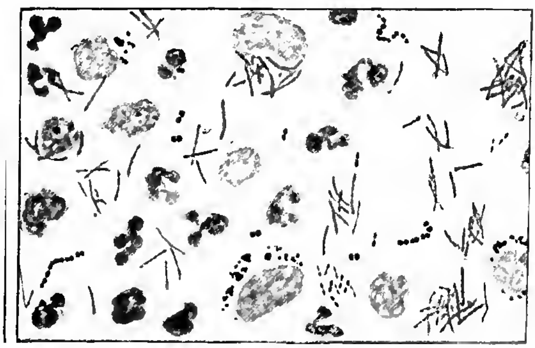


FIG. 138.—Illustrating the germ theory of heredity.

docked of their tails for centuries without shortening in the offspring. Then, if it be not through the germ that we inherit, how do male qualities pass through the female, and female through the male? The lovely soprano voice of the mother may be inherited through the son to the granddaughter, the black beard of the father may pass through the daughter to the grandson; bleeder's disease or too ready bleeding passes through the female without occurring in the females themselves (the father bleeds—his daughter does not bleed—her sons bleed).

Experiment does not disclose much connection between body and germ. Thus W. E. Castle and J. C. Phillips transplanted the ovaries of a guinea-pig of one colour to a guinea-pig of another colour,





(1) The minute spiral organisms of syphilis.

(2) The organisms of consumption.

(By the courtesy of Robert Muir, University of Glasgow.)

and the transplanted ovaries produced living young resembling the original animal, not the one into which the ovaries were put. Again, if the relation between body and germ were a close one, there should also be a definite relation between the conditions of the body and the incidence of sex in the birth-rate. That has never been proven; the birth-rate of the chief Scottish towns shows the same proportion of male to female children, 51 to 49 in a 100, whether conceived in the six cold winter months or in the six warm summer months.

So runs the argument. And the social deductions are not slow in following, as follows :—

If people live in slums and poverty, it is a pity for *them*, for they get too little to eat and too much to drink, and so their germ-tissues get poor food, and their children will then be less sturdy, but there is no direct stamping of the evil circumstances of the slums upon them. The race is as good quality as ever, only a trifle thinner or smaller in quantity, because the germs of the parents were badly nourished: feed them up, and all will be well as before. On the other hand, a bad stock remains a bad stock; we are the predetermined effects of bad hereditary determinants, 32 male and 32 female; if our parents are rotten, we must be rotten too.*

Clearly, if this be the case, if a man is doomed bad from his birth, there is no sense in wasting money and time in public education, in training children beyond their natural station. To quote R. H. Lock (*Variation, Heredity, and Evolution*) :—

> 1. "We think that the inheritance of acquired characters may be disregarded as a practical factor in evolution" (p. 320). ". . . The principles of heredity teach us that education and training, however beneficial they may be to the individuals, have no material effect upon the stock itself. If they have any effect at all, this is undoubtedly unimportant in comparison with the effect which would be produced by selection of individuals who exhibit desirable qualities. The demand for a higher birth-rate ought to apply strictly to desirables. Instead of this the cry is for education and physical training, processes which can have no permanent beneficial effect upon the race" (p. 322).

* Weismann, *The Evolution Theory*, vol. i. p. 388; *cf.* Charles Darwin, *Animals and Plants*, vol. ii. p. 60: "Transmission and development are distinct powers."

> 2. Karl Pearson (*Grammar of Science*, vol. i. p. 28): "From a bad stock can only come bad offspring, and if a member of such a stock is, owing to special training and education, an exception to his family, his offspring will still be born with the old taint. Now, this conclusion of Weismann, if it be valid—and all we can say at present is that the arguments in favour of it are remarkably strong—radically affects our judgment on the moral conduct of the individual, and of the duties of the State and society towards their degenerate members. No degenerate and feeble stock will ever be converted into healthy and sound stock by the accumulated effects of education, good laws, and sanitary surroundings."

If this be true, if the same process of betterment has to be laboured through by public authorities in each generation with inadequate and futile results, it is not difficult to see how enthusiasm for social reform may be damped down; we shall neglect the freedom of the individual and shall look instead to the State to pass stringent laws forbidding marriage among the diseased and criminal stocks, and permitting only the fit to procreate (Eugenics).

The Problem of Design.

Thus we are all dead machines, devoid of guiding design. In the words of Charles Darwin himself: "Now that the law of Natural Selection has been discovered, one can no longer argue that, for instance, the beautiful hinge of a bivalve shell must have been made by an intelligent being, like the hinge of a door by man."

And in a letter of Asa Gray in America, dated 22nd May 1860: "I see a bird which I want for food, take my gun and kill it; I do this *designedly*. An innocent and good man stands under a tree, and is killed by a flash of lightning. Do you believe (and I really should like to hear) that God designedly killed this man? Many or most persons do believe this; I can't, and don't. If you believe so, do you believe that when a swallow snaps up a gnat that God designed that that particular swallow should snap up that particular gnat at that particular instant? I believe that the man and the gnat are in the same predicament. If the death of neither man nor gnat are designed, I see no good reason to

believe that their first birth or production should be necessarily designed."

A mother bears an only son. A few bacteria settle on the coats of his bowel, the inflammation of appendicitis ensues, then suppuration, and another youth, full of promise, has gone to feed a few

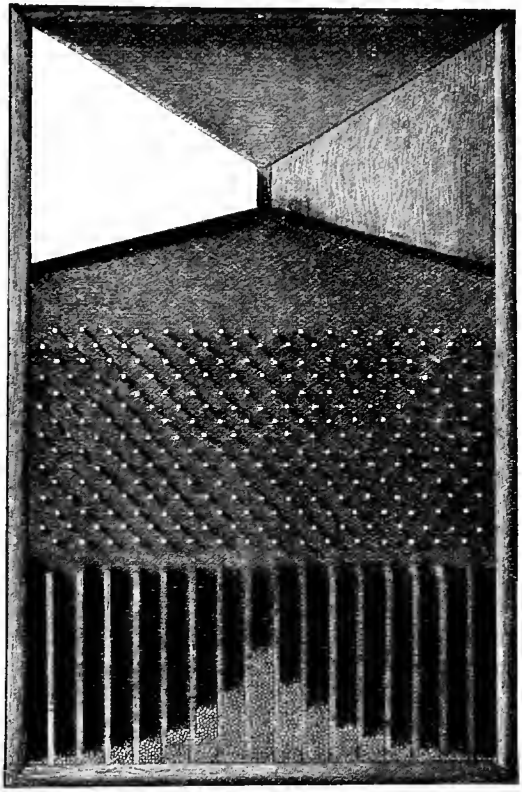


FIG. 139.—Galton's Chance board.

Small shot are dropped into the slot and trickle through between the nail into the columns below.

bacteria. Is it not a mockery? In Weismann's words, "Does not the hypothesis of a predestinating power of development suffer utter shipwreck in face of facts like these?" Or in Darwin's words, "This very old argument from the existence of suffering against the existence of an intelligent First Cause seems to me a strong one."

Man and Nature are like the wind, "with the details whether good or bad left to the working out of what we may call chance." Therefore Darwin says, "I for one must be content to remain an agnostic." And again he asks, "Have we any right to assume that the Creator works by intellectual powers like these of man?"

His follower, August Weismann, voices this in these words: "We have no reason to refer the thousands of cases of harmonious adaptation, which occur among animals and plants, to a principle,

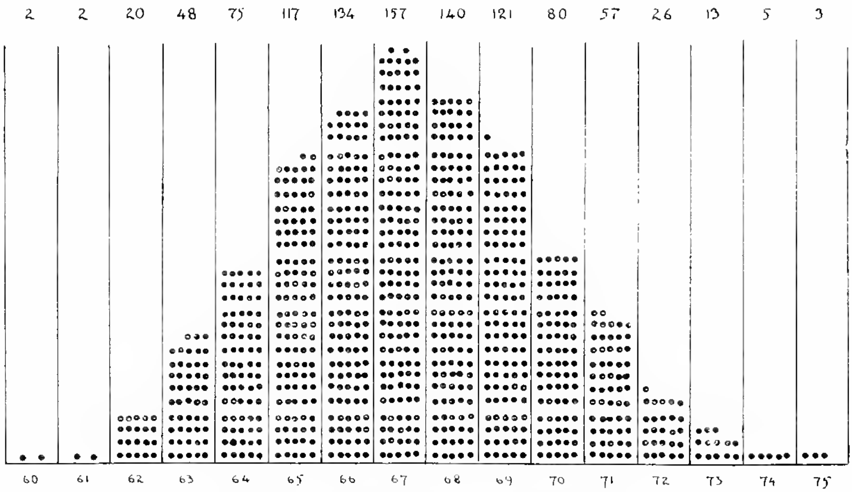


FIG. 140.—Heights of 1000 American soldiers.

The numbers on the base line represent the height in inches. The dots represent the number of soldiers to each height.

The Law of Chance maintains that as the bullets on the chance board and the heights of the soldiers are distributed into similar columns, man must obey the Law of Chance in his stature.

the active intervention of which in the transformation of species is nowhere proven. We do not require it to explain the facts, and therefore we must not assume it."

Or to put it bluntly, there is no Intelligence beyond that of the well-educated man.

The rest is easy, both to individual and to nation. If man be but a chance mushroom on a mechanical dungheap, then, in the words of the Persian Omar Khayyám, "One thing is certain, and the Rest is Lies; The Flower that once has blown for ever dies."

"Ah, fill the Cup :—what boots it to repeat
How Time is slipping underneath our Feet:
Unborn To-morrow and dead Yesterday,
Why fret about them if To-day be sweet!

One Moment in Annihilation's Waste,
One Moment, of the Well of Life to taste—
The Stars are setting, and the Caravan
Starts for the Dawn of Nothing—Oh, make haste!"

The Nation.

And if the nation be but only a combine of force struggling—after the teaching of Charles Darwin—to survive amid a world of antagonists, as do the trees of the forest for a place in the sun,

Fig. 141.—The effect of Force upon a German soldier.

then that nation with the greatest force will prevail over the rest. Then comes the easy descent :—

1. Trust in man's intellect begets a belief in external force.
2. Force begets navy-machines and army-machines and aero-machines.
3. These machines beget abandon of direct government by the people.
4. Loss of direct control by the people spells war.
5. War is the reckless conversion of human lives into corpses.
6. Destruction of life is death to the home, present or to be.

Once upon a time a man received the gift of a motor-car. But he was warned, "Do not use this car, for it has no brakes; this type of machine is built only for show." The man obeyed at first. He built a beautiful shed for his car, dry and warm and airy, and

he kept it oiled with care and dusted it every day, until its bonnet and silver sparkled in the sun whenever he wheeled it out. He used to wheel it out every day but Sunday, and used to pat it lovingly, for it was his own. But one fine day he said to himself, " Why do I keep my car in its house ? Had I not better test it out a little upon the road ? " So he started the engine, and took it safely through the front gate, which it filled almost, for the car was really a big one. He ran it along the road. He came to the top of a hill and down it he sped, the dust rising behind him. But at the foot of the hill was a cross-road, crowded with men and women and children. And the car dashed into them and hurt several of the youngest children, the ones who could not run out of the car's way quick enough.

Gaze down. Our valley is a carpet of green and yellow beneath our feet. It looks lovely. It seems very busy. But listen, spanning it all, like a great vulture surveying the abyss, there broods the unanswering stillness of death.

Part II

THE MOUNTAIN

SUMMARY

THE MOUNTAIN

FIRST STEP.

THE SPIRIT OF SEARCH.

PLATO tells of the man who lives all his life in semi-darkness, inside a great cave or mine, until he had grown to be part and parcel of it; until every nook and every cranny is linked in his mind with some personal interest, until the beauties of every crystal and every stone are sacred and riveted to his affections. Now, let such a one be visited by a dweller on the earth, this world of sunshine and the open road, of the dew sparkling amid the heather, the snow as it clouds upon the clear black-purple mountains, of misty waterfalls and darkly murmuring forests, of the foam and swirl and swish of the waves upon the sand, the red poppy as it stares from out the green and yellow corn, of the challenge of the storm and the sting of the leaping spindrift. He climbs laboriously down into the dark, and says, " This smells like rheumatism." He greets the denizen of the cave with the words :—

" Really ! What are you doing in this dark hole ? Come out of it at once."

But the cave-dweller replies :—

" You are mad. Who are you that ask me to leave my old and lovely associations in search of what *you* call beauty ? Prove to me that your boastings are superior to what I here display. Look at this precious gem I have found ; can you match that ? "

" No," says the visitor, " I can't ; but above there everything looks so different, so much wider and airier. You do not understand what light and height and distance mean."

" Oh, don't I ! " retorts the cave-dweller. " Cast your eye along that tunnel. Is not the distance enormous ? Although the light at this point is very bright, your eye cannot even attain the farthest

end of it; and can there be any distance farther than the limits of my utmost vision?"

But he forgot the penetrating remark of Liebig, "The secret of all who make discoveries is that they look upon nothing as impossible." He forgot that the only thing perfect is a perfect fool. He imagined that his own provisional view of Nature was the absolute, constant, and rigidly unalterable truth. Which was a mistake. For the march of knowledge is marked by palatial milestones, each based on a foundation broader than the last.

One further point. Let no inquirer ever seek to squeeze money out of search. An example. Following up the theoretical work of the Frenchmen Ampère and Coulomb, the Englishman Faraday, the American Henry, and the Scot Maxwell, the German physicist Hertz in 1887 established that electro-magnetic waves can be sent right through space. What more unbusiness-like discovery could well be made? One can overhear the jibe, "An electric wave through the æther! Unpractical! No money in it!" Ah, but the Italian Gulielmo Marconi, born of an Irish mother, seizes the idea, perfects the metal-filling receiver of the Frenchman Branly, and renders it a practical instrument to record the movings of invisible matter. Wireless telegraphy is the result. A doomed ship can now signal for help. To-day Marconis are quoted on the Exchanges. Yet what man so daring as estimate the value of human life in terms of hard cash!

SECOND STEP.

THE METHOD OF SEARCH.

Seek. See. Seize. Follow. Forbear.

How scale this barrier of rocks and overhanging boulders? Silently humble.

Without conceit in the past, without fancy of the future.

For to assume is to presume.

A healthy dissatisfaction is not the same as a discontent.

Accept not for true on the bare assertion. Verify.

For it is usually ignorance which keeps people content with the

worse; or, in the pithy word of Shakespeare, "There is no darkness but ignorance."

Step by step, in faith; defined by Paul the Evangelist as the substance of things hoped for, the evidence of things not seen. Test on test: if right, well; if wrong, learn. Your first guess or theory contains some of the facts, but not others; discard it, try another, find it meagre; and so on. The greater the number of facts properly

Fig. 142.—Leonardo da Vinci.

comprised by your supposition and the simpler its statement, the nearer it comes to be a general law of Nature. In the words of Leonardo da Vinci (1452–1519), of Florence and Milan:—

> "Experiment is the interpreter of the artifices of Nature. It is never wrong; but our judgment is sometimes deceived because we are expecting results which experiment refuses to give. We must consult experiment and vary the circumstances till we have deduced from it general laws, for it alone can furnish us with them."

Knowledge advances by the waiving of assumptions, however seemingly opposite.

Patience on patience, anger on anger, confidence on confidence.

The Matterhorn was not surmounted first attempt.

The tides are still to be harnessed.
There are seas and seas uncharted to explore.
Rely not on the ear so much as on the eye.
For your ear is another's, the eye is your own.

No single belief but is based on some foundation, yet is hearsay a leaf in autumn, blown from the trunk that bore it. Granted the possession of honesty, a deduction from observation should carry more weight than reasoning that arises from the statements of others. The observations of others, while probably better than our own, are no substitute for our own. For the eye is exacter, albeit more exacting, and by it we measure.

Tycho Brahe's advice to the young John Kepler upon presenting him with some wild astronomical theory was "first to lay a solid foundation for his views by actual observation, and then by ascending from these to strive to reach the causes of things."

Most of our eyes start equal. But it is one act to see a thing, another to understand it. In the words of Paul, with the spirit and with the understanding also. A man may see, and yet see nothing. A British soldier was once shot through the back of the head and through the seeing lobes of his brain. His eyes and eye-nerves appeared to be quite intact, but yet to him the world was utter darkness.

It was Dr Joseph Bell of Edinburgh, who is the Sherlock Holmes so skilfully portrayed by Arthur Conan Doyle. "You see that man who has just stepped in," he would remark to one of his students, "tell me his story." The student would make to inquire of the man himself. "But stop!" said Bell; "you can surely see it without asking. Here, my man, will you be so good as correct me if wrong? To-day is Monday, but you injured yourself on Saturday, for it was splashing wet then and dry yesterday, and the mud still clings to your trousers. By its colour I perceive the district you hail from. You received your pay, shipped some liquor, and fell with your weight on the grate, for your trousers are singed at the knee. You limped when you entered. Your complaint is a burn on the leg. Is that correct?" It was.

And the conversations between Sherlock Holmes and his friend Dr Watson gain their interest not so much from the detective having

seen more than the other, but because even out of the seemingly simple things of our everyday life he infers or deduces or imagines more, and so sifts and analyses the past events ; the colour of a hat, the fraying of a glove, the flourish of a pen, the pressure of a thumb-print, the flattening of a boot, all have their meaning to the detective. And when they both see the 2 and 2, the detective is the first to associate them to make 4. In his own words, " Let me run over the principal steps. We approached the case with an absolutely blank mind, which is always an advantage. We had formed no theories. We were simply there to observe and to draw inferences from our observations. What did we see first ? " To see a thing is not necessarily to realise it. Open to receive !

FIG. 143.—Francis Bacon.

Follow up, whenever possible. Is truth ever barren, though despised ? To climb down is even more dangerous. In the utterance of Francis Bacon (1561–1626) :—

> " Yet truth, which only doth judge itself, teacheth that the inquiry of truth, which is the love-making or wooing of it ; the knowledge of truth, which is the presence of it ; and the belief of truth, which is the enjoying of it, is the sovereign good of human nature."

Which again is insufficient. Very much so. In the sentence of William Hamilton : " Truth is like a torch ; the more it is shook, the more it shines ! " Any truth we attain is but a pledge of more, an earnest. As it ousts its earlier aspects, so it stands itself ready to be ousted. In the words of the song, wider still and wider shall thy bounds be set. Which naturally takes time ; for unless for cash, nothing worthy becomes acceptable except through the successive stages of neglect, contempt, contention, and a faint support ; as indeed every man encounters when he seeks a new job. Truth is not absolute ; it grows in eras ; it is strong to judge itself ; it lives in awe. It resembles the radiating rings of a still pool into which a stone is dropped.

Frequent attempts have been made to quench the torch. Never ! though it has often been guttered down. Opinion is a form of physical strength, and so, not unnaturally, believers in the past

have used physical strength to crush it. And in the early days when research was perhaps more exciting than to-day, you had to back your opinion with your body. " I believe in an infinite Universe," said Giordano Bruno, and was burnt at the stake. In his travel through Germany as a young man, Tycho Brahe, the Swedish astronomer, became interested in a dispute with a nobleman of Denmark on a questionable point of geometry. According to the narrative of David Brewster, the two mathematicians resolved to settle the difference by the sword. Tycho, however, seems to have been second in the conflict, for he lost the greater part of his nose, and was obliged to supply its place by a substitute of gold and silver, which a cement of glue attached to his face.

Apart altogether from the issue of human life, it is in practice difficult to persuade a man by dashing his brains out. And ever clearer does it appear we can hold robustly and resolutely to our own belief, without stint to the gain of others. Their gain is our gain, their loss our loss. There is no sincerer test of our courage and ability than this. Are we prompt and tolerant to sink our own view on the presenting of a better ?

Observe ; analyse ; compare ; forget ; devise.

THIRD STEP.

THE NEED FOR INQUIRY.

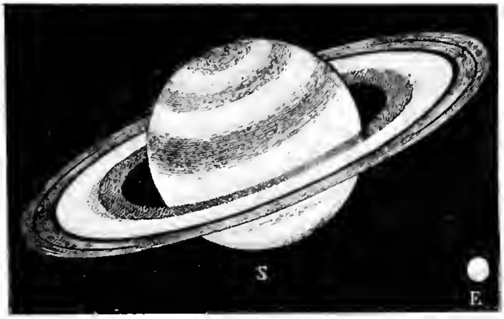
(This varies from time to time.)

In the first part of these pages reference was passed on two beliefs of Western men, grasped usually under the terms " Atoms " and " Natural Selection." The first usually held to explain element, the second tissue. Both merged within the idea of the conservation of force applicable not merely to matter but also to the workings of man himself. These ideas are open to criticism, as in this way :—

Atoms.

What is their shape ? Are they round—as are the planets—or oval, or disc-shaped like the small red bodies of the blood, or are they rectangular cubes, or lopsided ?

No two sand grains on the shore are exactly alike. Are no two



(*After Ball.*)

FIG. 144.—The planet Saturn and the planet Earth.

FIG. 145.—Human red blood corpuscles, greatly magnified.

(*Photo by T. C. Day, Edinburgh.*)

FIG. 146.—Sand grains magnified some 400 times.

atoms exactly alike? Is the particle of common salt one shape, the particle of mustard another shape, the particle of olive oil a

third shape? Do they all differ in movement, state of temperature, and electrical condition? When water is heated into steam, do the particles swell, and if so, how much do they swell? Are there little spaces between the particles, or do they stick together into clumps like toffee? Why when you set a bowl of water out on a frosty night do you find the frozen water, "ice," has expanded and risen in the middle of the bowl and up the sides of your bowl? Why do water-pipes sometimes burst in frosty weather? Is it that the cold has made the particles of water expand? Such a notion is not readily comprehensible.

Western man has pictured to himself smaller and smaller particles—"grain," "particle," "molecule," "atom," "semi-atom," "electron," each smaller than the last, like the boxes of a Chinese puzzle. They are the instruments of his calculations. But until he first clearly determines the actual shape of these bodies, he misses surety and extent, and tends to waste the precious time of those who tread after him.

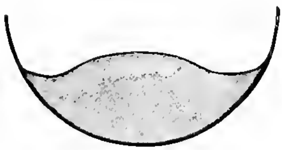


Fig. 147.—Water to ice.

We are each allotted a seventy years' span, and it is not rendered more fruitful by such idle and miniature projections of the fancy.

Natural Selection.

Charles Darwin says plants, animals, and man are the direct outcome or mould of the external forces of Nature, the "environment." Is this correct?

Consider there are three difficulties to this view:—

1. The want of harmony between environment and tissue form.
2. The origin of form.
3. The retention of form.

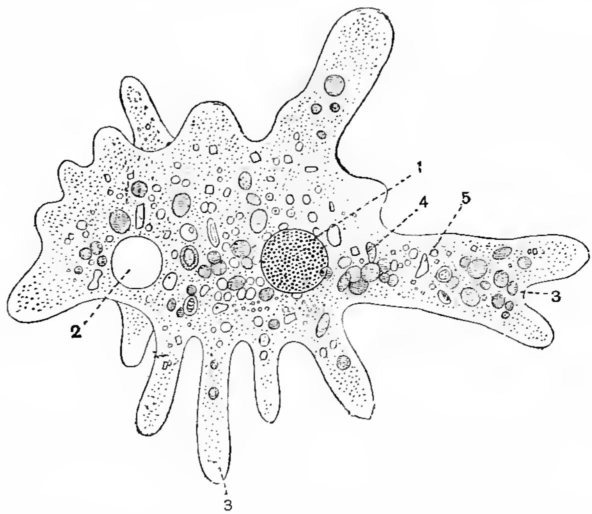
Then let us briefly instance.

First Difficulty: The Environment Form Discord.

The regions of the earth's surface merge more or less gradually the one into the other; the species of plants, animals, and man do not; the Polar bear does not blend by intermediate forms into the African lion.

Natural Selection maintains: The outer world is measure of the organism. Geography replies: It is not!

For intermediate forms are rare. Embedded in the earth's crust we find, not an unbroken chain with perfect links, but vestiges of distinct forms similar to those which exist to-day: snail—crab—worm—gill-fish—lung-fish—frog—reptile—bird—kangaroo—dog—monkey—ape—man.



(*After A. E. Shipley and E. W. M'Bride.*)

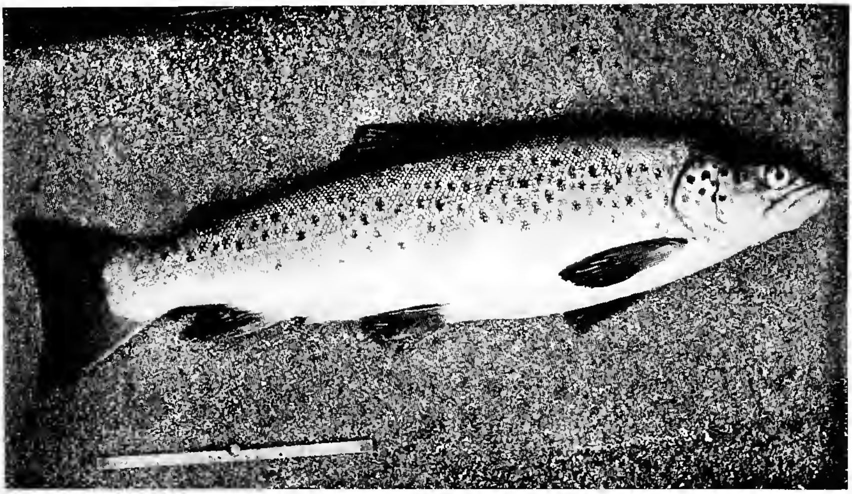
FIG. 148.—The minute jelly Amœba, magnified: a simple creature found in ditch-water.

(*After J. Graham Kerr.*)

FIG. 149.—A lung or mud-fish; the South American *Lepidosiren*.

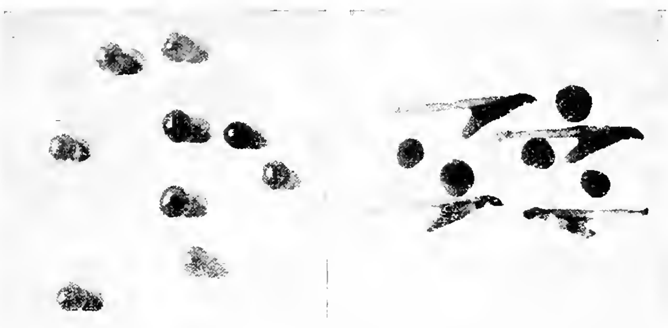
Vestiges there indeed are—instance the reptile-bird known as the Archæopteryx, half bird, half crocodile with its toothed bill, wings, and long tail (figs. 153 and 154); and those two peculiar Australians, the duck-bill and the spiny ant-eater (figs. 155 and 156), which still live to link birds with the mammals, for though they suckle their young they lay them first as eggs. Other vestiges indicate an intermediate stage or offshoot between ape and man, such as the Java man discovered by the Frenchman Dubois, the skull capacity

of which is well under even that of the Australian bushman; the experts have disagreed over it, some holding it for an ape, others believing it was once a man.



(*After P. D. Malloch, Perth*)

FIG. 150.—A Scottish trout, with 6-inch rule alongside.

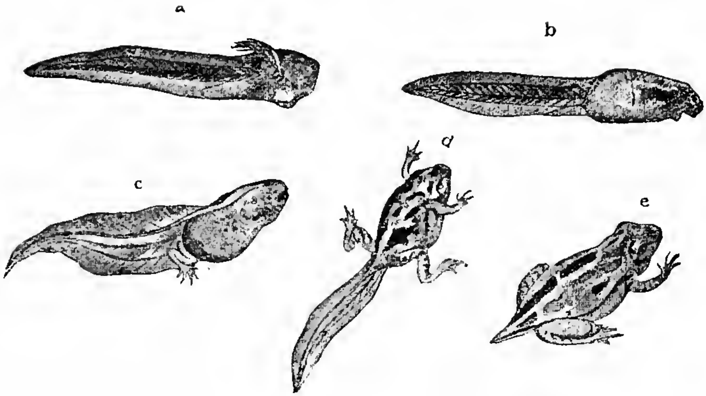


(*Lent by Mr Henry Lamond, Secretary of the Loch Lomond Angling Association; from "The Sea-Trout."*)

FIG. 151.—Sea-trout eggs and sea-trout alevins hatching out.

And Nuttall and Friedenthal, analysing the bloods, found the differenee between monkey-blood and man-blood to be greater than between ape-blood and man-blood.

Nevertheless, such intermediate links are the exception rather than the rule.

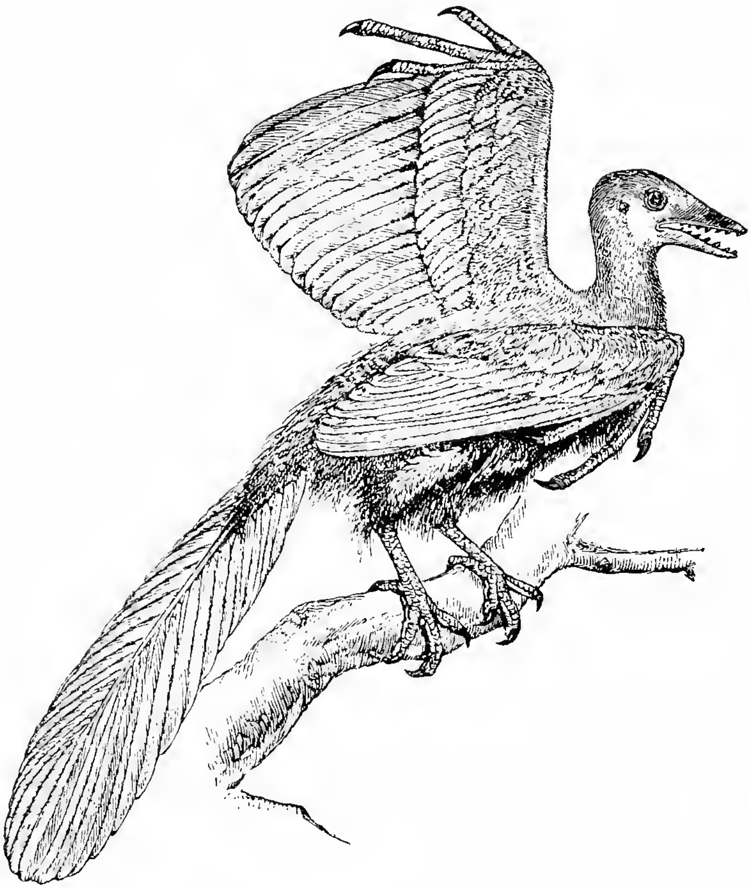


(*After William Leche.*

FIG. 152.—Betwixt tadpole and frog.

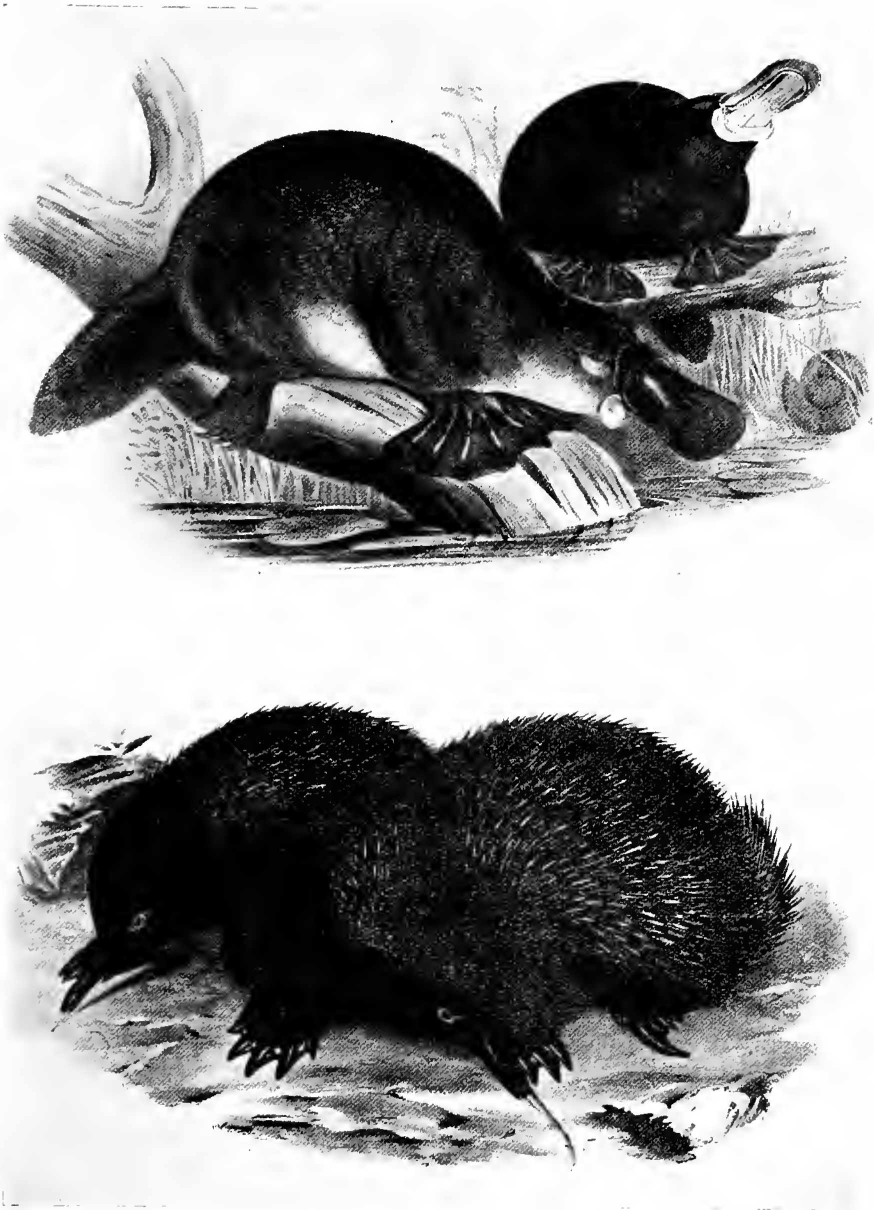
(*Through the proprietors of the " Encyclopædia Britannica."*)

FIG. 153.—The Archæopteryx : the Berlin specimen in stone.



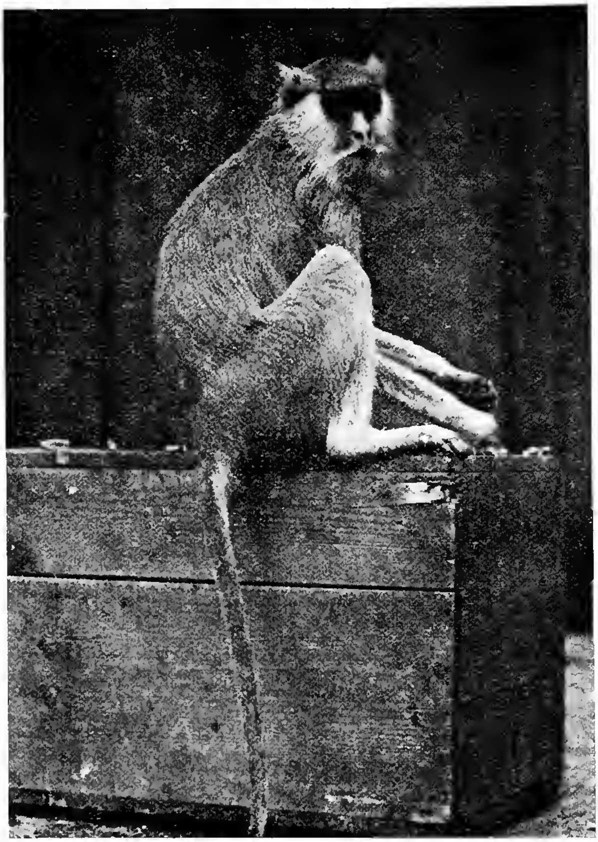
(*After William Leche of Stockholm.*)

FIG. 154.—The Archæopteryx: the restored specimen.



(*After John Gould.*)

Figs. 155 and 156.—The Australian duck-bill and the Australian spiny ant-eater: linking birds with mammals.



(*Photo by F. W. Bond.*)

FIG. 157.—A monkey : the Zoological Society of London.

(*After Heck.*)

FIG. 158.—Young chimpanzee.

(*Photo by F. W. Bond.*)

Fig. 159.—An orang: the Zoological Society of London.

Fig. 160.—An elderly orang: the Zoological Society of London. Observe the forehead.

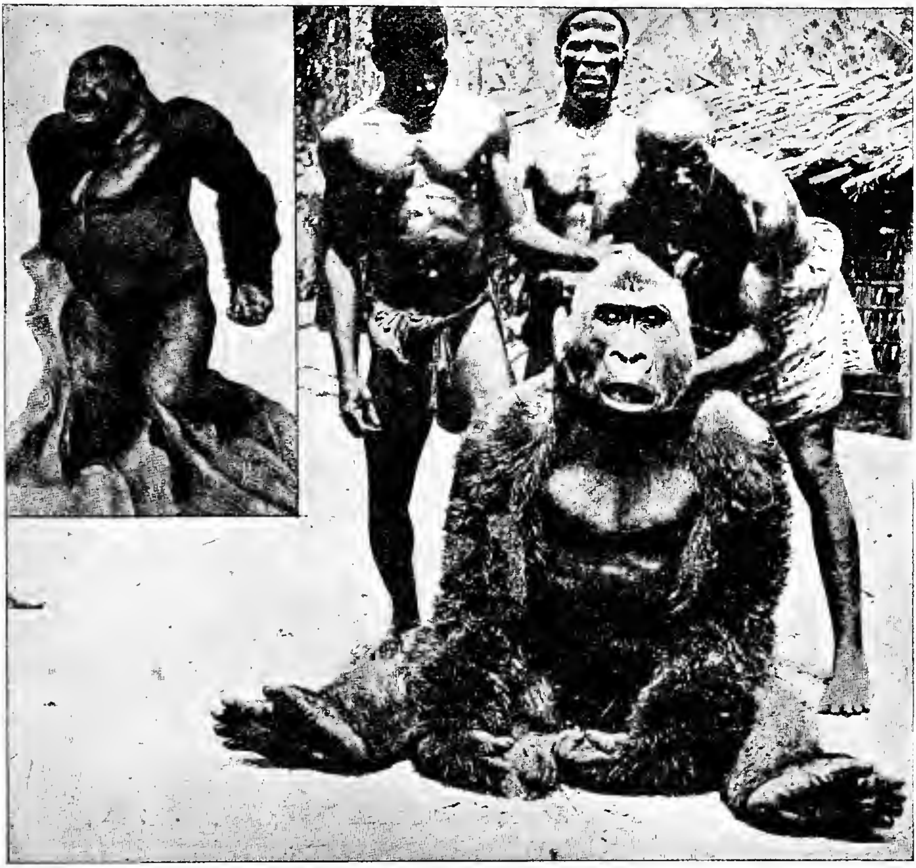
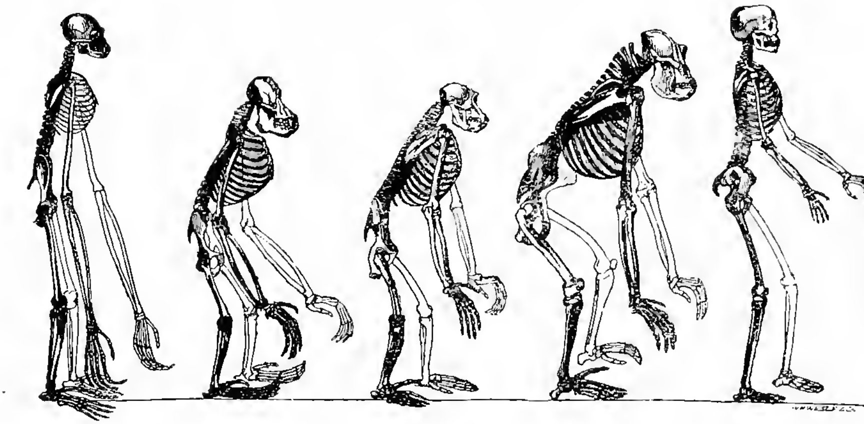


FIG. 161.—Female gorilla.

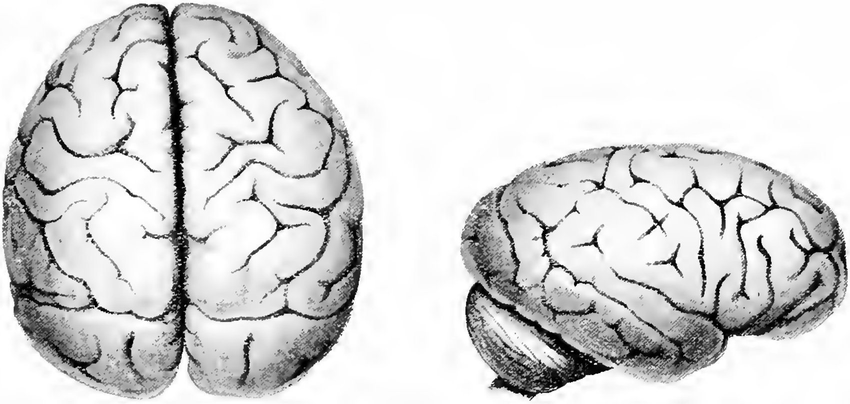


(*After T. H. Huxley (Messrs Macmillan).*)

FIG. 162.—Skeletons of the gibbon, orang, chimpanzee, gorilla, man. Photographically reduced from diagrams of the natural size (except that of the gibbon, which was twice as large as nature) drawn by Mr Waterhouse Hawkins from specimens in the Museum of the Royal College of Surgeons.

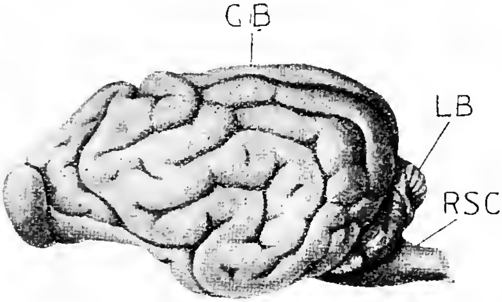
(*After Romanes and Pycraft.*)

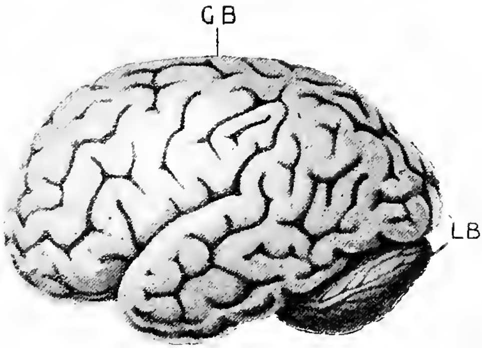
FIG. 163.—Infant three weeks' old that maintained its hold for over two minutes.



(*The original drawing lent by William Leche of Stockholm.*)

FIG. 164.—Brain of chimpanzee, seen from above and also from the side.





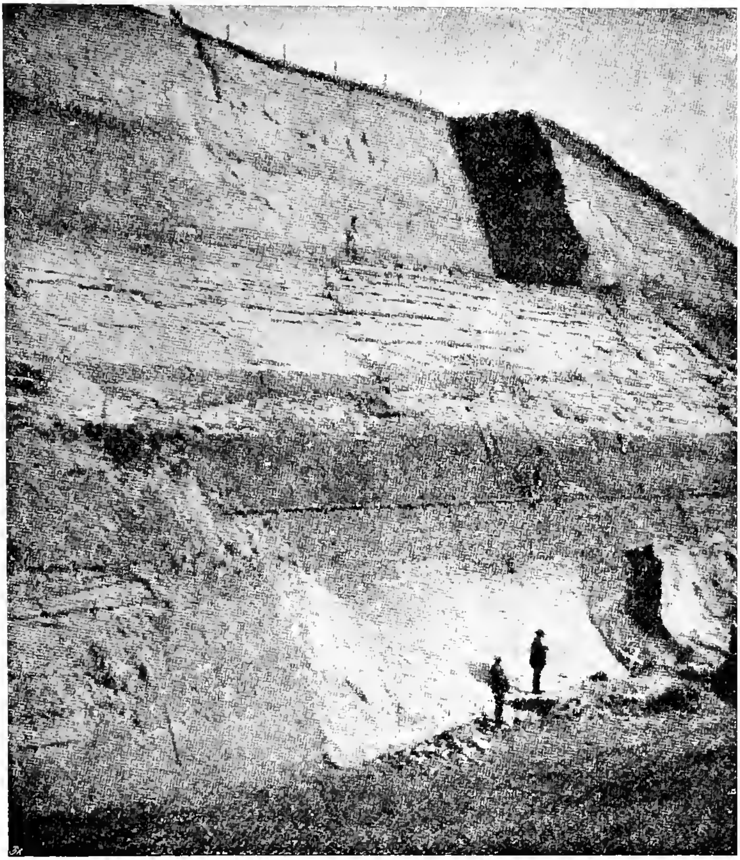
(*After William Leche.*)

FIGS. 165 and 166.—Brains of dog and man.

GB. Greater brain. LB. Lesser brain. RSC. Root of spinal cord.

(*After Rutot. From G. F. Scott Elliott, "Prehistoric Man and His Story," Seeley, Service & Co., London.*)

FIG. 167.—The Java man, or missing link, reconstructed.



(*After Schoetensack and Leche.*)

Fig. 168.—How it is possible to quarry for remains of prehistoric man in the deep layers of the earth. Geological layers near the town of Heidelberg.

(*After E. T. Reichert and Amos P. Brown, The Illustrated London News.*)

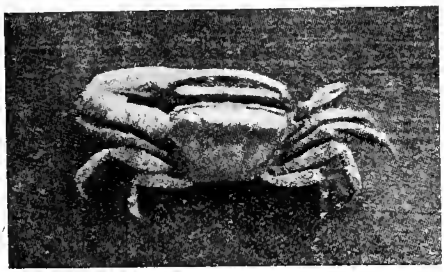
Figs. 169, 170, 171, and 172.—Blood crystals of dog, gninea-pig, man, and orang.

There are other discords. Everything that is, is useful, avers Natural Selection. But the form of plants and animals may either fall short of or overshoot the environment.

Falling Short.—Why is the fiddler crab lopsided and short in one claw ? Is this useful ? If so, why have not other crabs the same ? Why this race of monsters ?

The giraffe has a long neck. How so ? Mr Darwin explains :—

> "In every district some one kind of anima' will almost certainly be able to browse higher than the others ; and it is almost equally certain that this one kind alone could have its neck elongated for this purpose, through natural selection and the effects of increased use."



(*After D. S. Jordan and V. L. Kellogg.*)

FIG. 173.—The fiddler crab.

(*From the Royal Scottish Museum.*)

FIG. 174.—Giraffe bending to drink.

But surely if it advantaged the giraffe to develop a long neck and to secure food, it would be unprofitable for the other creatures to have to do with less food. They likewise should have long necks.

Natural Selection fails to explain the differences of tissue.

Scottish farmers are well aware of " sow-mouthed " cattle : the dealers try to pawn these off at sales, but as they have very short lower jaws, they are unable to short-crop in dry seasons and require to be fed by hand. But this quality is clearly not of profit to the cattle, but rather the reverse.

Worker ants are sterile, unable to reproduce; they have lost their wings, their eyes have degenerated. How could this have occurred merely through external action? Are not the workers exposed to the same light as are the others?

Or wherefore has the Manx cat got no tail? Darwin is obliged to confess:—

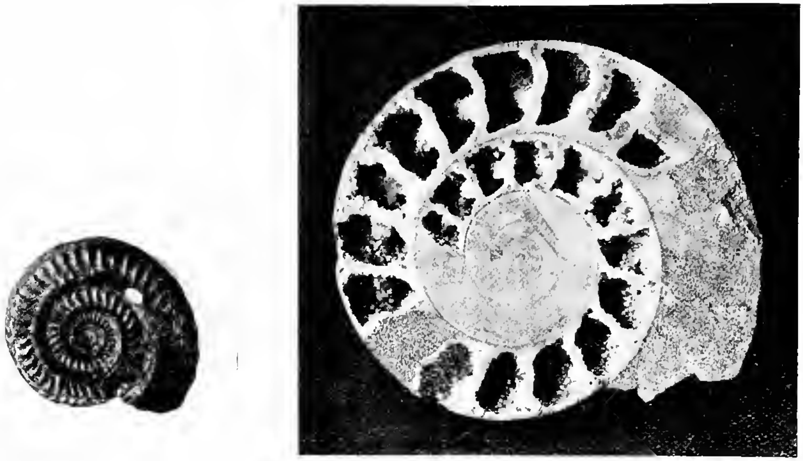
> "We do not know through what steps under Nature rudimentary organs have passed in being reduced to their present condition. . . . Even if an organ did suddenly disappear in some one individual by an arrest of development,

(By permission of Horace Donisthorpe, "British Ants.")

FIG. 175.—Male, female, and worker ants.

> intercrossing with the other individuals of the same species would tend to cause its partial reappearance; so that its final reduction could only be effected by some other means."

And the same difficulty is seen in the disappearance of races. Do they not emerge from the mists of the past, bear the heat of the day, only to falter and faint, giving place to higher forms? The ammonites are extinct molluscs, but found in the earlier rocks of the earth in innumerable multitudes. The pearly nautilus with its beautiful coiled and chambered shell is their nearest living ally. How did Natural Selection allow them to be at one time so numerous, and now so few? We know of no change of climate so sudden as to prevent the animals changing to meet the new conditions; surely if some of these ammonites could only be transplanted alive from their fossil beds to modern waters they would flourish; and even if some great change swept many of them out of existence, why did not some of them escape to repeople the seas. If they gradually died off by becoming less and less fertile, wherein lay the advantages

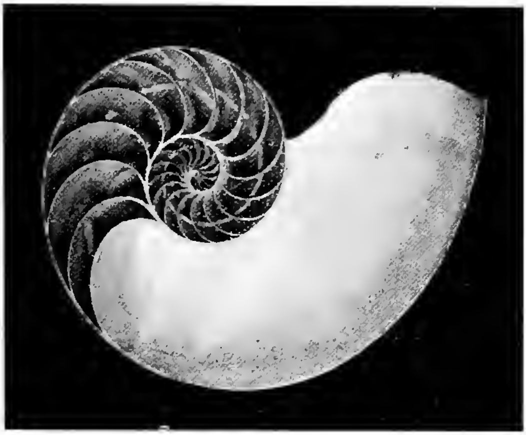


(*Hunterian Collection, University of Glasgow.*)

FIG. 176.—Ammonites, fossilised ; the second cut in section and showing quartz crystals within the chambers.

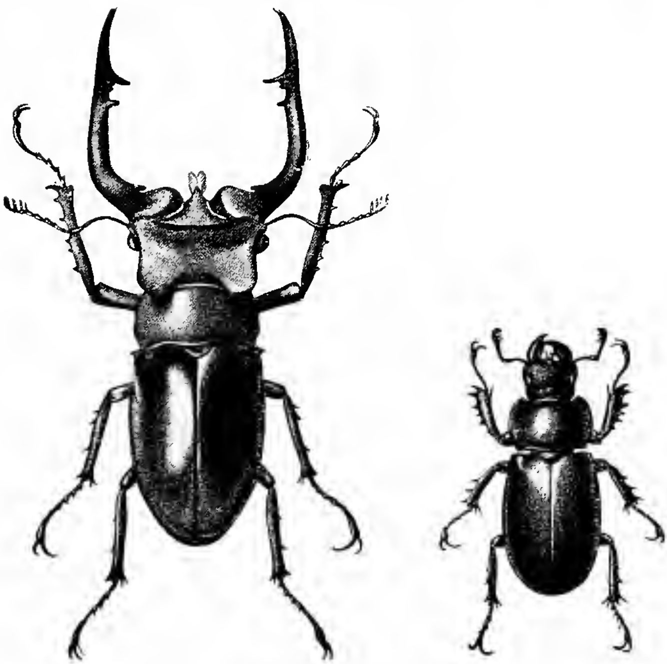
(*Geological Museum in London.*)

FIG. 177.—Ammonites embedded in a block of marble.



(*Hunterian; from a print lent by Mr Kinghorn.*)

FIG. 178.—A pearly nautilus.



(*After E. B. Stebbing, " Indian Forest Insects." Presented by Messrs Eyre & Spottiswoode of London.*)

FIG. 179.—Male and female of one species of beetle.

to the race? Is it profitable to a race to commit suicide? How does Natural Selection explain an increasing sterility? How does it explain all such forms of "degeneration"?

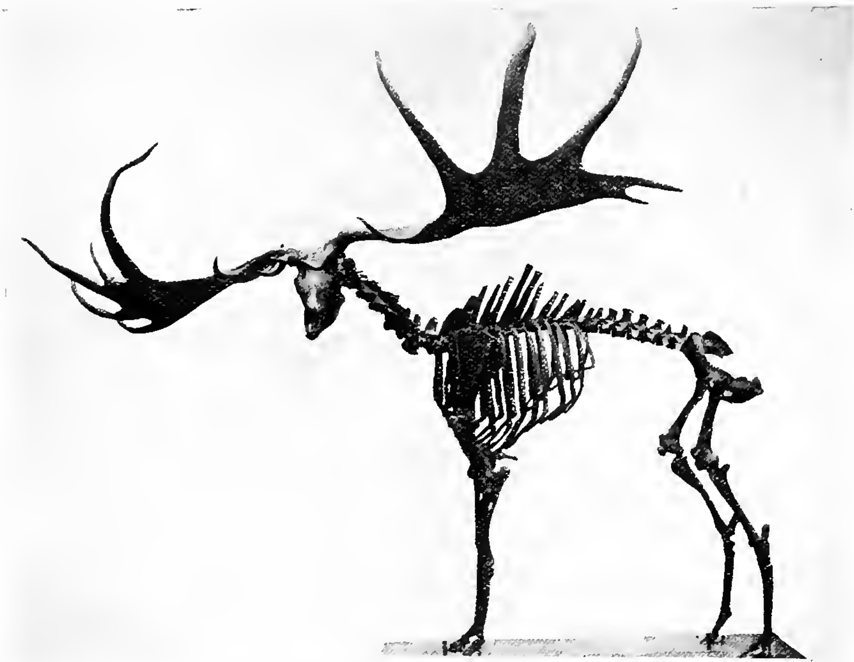
So it would seem that at times tissue change falls short of the demands of Natural Selection.

(*Lent by the American Museum of Natural History, New York.*)

FIG. 180.—A tusker mammoth.

Overshooting.—Consider the lilies of the field. The colourings of flowers, the spottings on the butterfly's wing, so remarkable that the male and the female of the species remained for many years under different names. The train of the peacock. The enormous tusks of the mammoth, and the extravagant antlers of the Irish elk. Were all the 100,000 varieties of beetle absolutely necessary? Only three varieties of the strawberry were known in 1746 in France,

where this fruit was early cultivated; "at the present day the varieties of the several species are almost innumerable." In India there are so many varieties of rice, and the varieties are so distinet to the Eastern taste, that sometimes the natives, even when starving, have refused rice imported from other districts, such as Borneo.



(*Negative by Peter M'Nair, F.R.S., of the Glasgow Corporation Art Gallery.*)

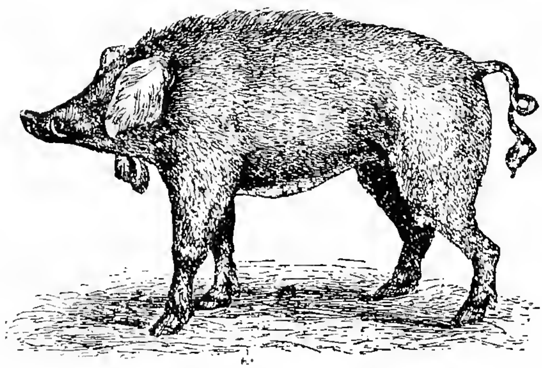
FIG. 181.—The Irish elk; displaying great spread of antlers. From a bog at Naul, County Dublin.

The overshooting of form over environment is seen not only in excessive diversity of form, but in the diverse ways by which a tissue attains an identical result in action:—

"It is a common rule throughout Nature that the same end should be gained, even sometimes in the case of closely related beings, by the most diversified means. How differently constructed is the feathered wing of a bird and the membrane-covered wing of a bat; and still more so the four wings of a butterfly, the two wings of a fly, and the two wings with

the elytra of a beetle. Bivalve shells are made to open and shut, but on what a number of patterns is the hinge constructed, from the long row of neatly interlocking teeth in a nucula to the simple ligament of a mussel" (Darwin, *Origin of Species*).

Or again, plants spread their fertilising pollen-grains in quite a variety of ways. Some simply by the wind. Others, like the flowers, secrete nectar, and so attract insects to carry their grains. The orchid even develops fertilising mechanism of the utmost complexity, one even pouring water into a bucket with a spout, attracting



(After H. D. Richardson and Charles Darwin: by permission of John Murray, London.)

FIG. 182.—Illustrative of overshooting. Old Irish pig with "useless" jaw appendages.

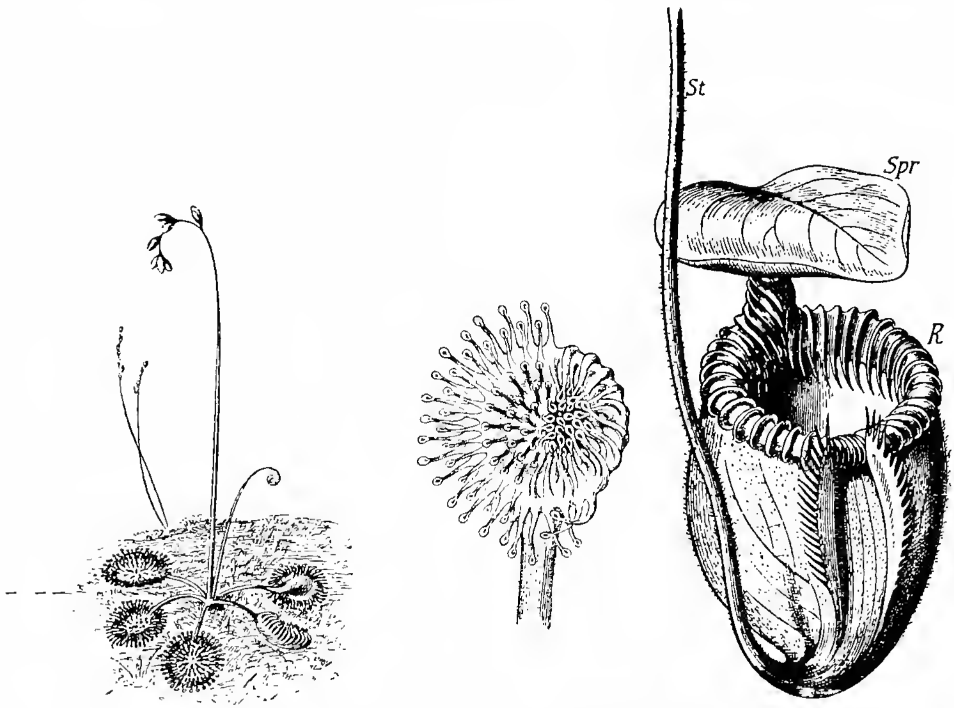
humble-bees by means of nectar ridges to fall into the bucket, and getting them to climb out by the overflow spout, where they rub against the pollen-grains and carry them away on their backs.

Such a calculating intensity of tissue is not easy to explain. Of course it is possible that the wonderful mimicry of the walking-stick insect to a dry stick, or the striking resemblance of the Kallima butterfly and certain night-moths to a leaf, arose from the action of outer environment picking out each occasional and haphazard difference in the direction of similarity. But this is not easy to believe—the resemblance is too acute. Take Alfred Russel Wallace's experience of the walking-stick insect:—

"One of these creatures obtained by myself in Borneo was covered over with foliaceous excrescences of a clear olive-green colour, so as exactly to resemble a stick grown over

> by a creeping moss. The Dyak who brought it to me assured me it was grown over with moss though alive, and it was only after a most minute examination that I could convince myself it was not so."

Moreover, the calculating socialism of some forms is not readily to be explained as a mere selection of haphazard varieties. In the

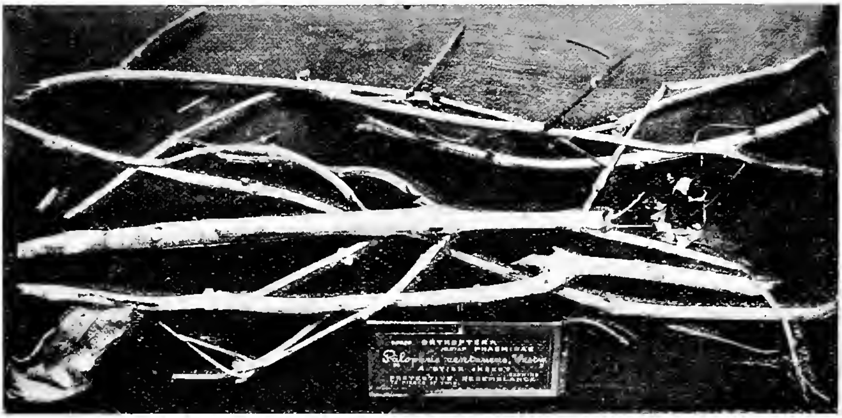


(*After Charles Darwin and August Weismann.*)

FIGS. 183 and 184.—Two forms of calculating adaptation in plants for eating flies.
(1) The sundew, with a leaf and tentacles bent upon a captured insect.
(2) The pitcher-plant, with its leaf-bucket contrivance and inturned spikes.

ants it was observed by Mr Busk, a backwoodsman of Texas; they even went the length of planting bushes for the shelter of their hills. The social instinct of the bees is also well known. You have two hives almost touching. Take a bee belonging to the first and place it on the stage in front of the second hive; it dies inside in a minute, stung to death. An even more complete socialism is sometimes

visible when between plant and insect; for instance, between the candelabra tree of South America and the Aztec ant. The candelabra trees carry leaves only at their tips. These leaves are menaced



(*Hunterian.*)

FIG. 185.—Calculating mimicry of walking-stick insect to stick.

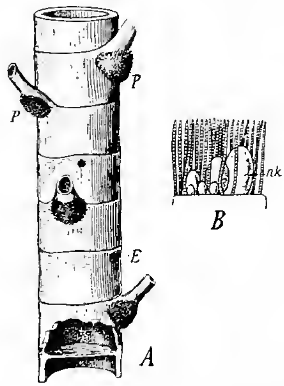
(*Hunterian.*)

FIG. 186.—Mimicry of leaf by Kallima butterfly: four leaves and three butterflies.

by the leaf-cutting ants. To defeat these robbers the candelabra tree has gone into partnership with another kind of ant, the Aztec, a sturdy fighter. It provides a home in its hollow-chambered trunk, and oozes food in the shape of a brown sap. It even provides little pits at intervals (E in fig. 187), so that the female Aztec may

easily bore her way into the interior; there she lays her eggs, and the whole inside of the tree soon teems with fighting ants.

Or take what Darwin called the correlation of variability. White cats with blue eyes are usually deaf. Polish fowls and tufted ducks and geese have a large tuft of feathers on their heads, associated with which their skulls are perforated by numerous holes, "so that a pin can be driven into the brain without touching any bone": even supposing Natural Selection explained the tuft itself, how does it explain the correlated perforation in the skull? Again, men with flaring red hair are often singularly nervous and excitable, and a



(*After Schimper and Weismann.*)

FIG. 187.—A piece of a twig of the candelabra tree, showing the sap cushions at the bases of the leaves for feeding its defender, the Aztec ant.

P. Sap papillæ. *B.* The same magnified.

tendency to consumption in man is often correlated with the presence of downy hair upon the back.

Then there is the endless complexity in the germ-tissues of plants and animals and man, a main factor in breeding, for it ensures that no two organisms are ever alike. Take any series of plants and animals you choose; some do not breed at all (sterility), others breed badly, others breed well and establish a fertile strain or line, like Abraham of old. These differences are out of all relation to the environment, and therefore are not explained by it.

In man the excess of form would appear in this. Man has a vermiform appendix (inflammation in which is appendicitis) attached to his great bowel. The apes have one also. Now, if the organ be advantageous to man and the apes, why is it absent from the

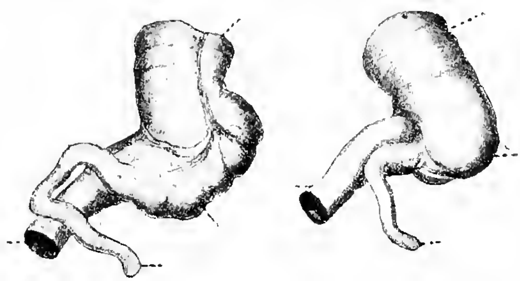
monkeys? And if it be an excessive thing in man, how does Natural Selection explain it?

Truly, contrasting the bare needs of the environment with the

(*After Charles Darwin.*)

FIG. 188.—Polish tufted fowl.

inexhaustible profusion of form and excessive diversity of function, Nature seems nothing but a senseless spendthrift; for Nature spends in excess of selection value, spends with open hand.



(*After William Leche.*)

FIG. 189.—The appendix of the orang (left) and man (right).

To sum up the matter:—

Sometimes there is an absence of strict harmony between tissue and environment. Sometimes the tissue falls short of the needs of the environment. Sometimes the tissue runs in excess of the

environment. And sometimes there does actually exist an antagonism between tissue and environment.

Second Difficulty: The Origin of Tissue Form.

How did the rudiment of an eye first appear ? Was it accidental ? Charles Darwin burks the question : " How a nerve comes to be sensitive to light hardly concerns us more than how life itself originated " (*Origin of Species,* chap. vi.).

Darwin does indeed admit the sudden arrival of new forms :—

> " Let us recall the case given by Andrew Knight of the forty-year-old tree of the yellow magnum bonum plum, an old variety which has been propagated by grafts on various stocks for a very long period throughout Europe and North America, and on which a single bud suddenly produced the red magnum bonum " (*Origin of Species*).
>
> " As a single variety of the chrysanthemum has produced by buds six other varieties, and as one variety of the gooseberry has borne at the same time four distinct kinds of fruit, it is scarcely possible to believe that all these variations are due to reversion. In such cases as that of the moss-rose there is no known natural species or variety from which the characters in question could have been derived by a cross. We must attribute all such cases to the appearance of absolutely new characters in the buds " (*Animals and Plants*).

And lastly :—

> " If we look to such cases as that of a peach tree, after having been cultivated by tens of thousands during many years in many countries, and after having annually produced millions of buds, all of which have apparently been exposed to precisely the same conditions, yet at last suddenly produce a single bud with its whole character greatly transformed (into the nectarine), we are driven to the conclusion that the transformation stands in no direct relation to the conditions of life " (*Animals and Plants*).

Darwin admits the new arrivals, but refuses to meet them :—

> " What the devil determines each particular variation ? What makes a tuft of feathers come on a cock's head, or moss on a moss-rose ? "

Herein Darwin is on the horns of a dilemma. For if the new forms arose by external selection acting on differences in plants and animals "by insensible steps," by slight deviations from the normal, then these differences could scarce be sufficiently pronounced and advantageous for selection to seize on; conversely, if the differences are marked, then these gains in a new direction could not immediately make up for the loss in an old and stable one, and the new forms would be swamped and die before even they were fairly clear of the threshold.

When the swim-bladder of the fish first began to change to

(After Kelway & Son, Somerset, introducers of the berry into Britain.)
Fig. 190.—Loganberries, half natural size.

become the lung of a frog, was that one particular animal not at a disadvantage as against its unchanging neighbours?

The survival of the fittest denies the arrival of the fittest.

Third Difficulty: The Retention of Tissue Form.

What comes, stays steady.

Wheat.—Upon this quality the Chinese Emperor Khang-hi selected rice to ripen north of the Great Wall, proving of high value to the inhabitants of Manchuria.

And in Scotland, in the spring of 1819, Patrick Shirreff observed on the farm of Mungoswells, by Edinburgh, in East Lothian, a single plant of a deeper green and heavier in head than the rest. He destroyed the surrounding plants to give it space, and manured it specially. After two years' multiplication it was brought into commerce as the famous Mungoswells wheat. Doubtless in the future afforestation of Scotland by its people the same quality of steady change will be pursued in the selection of the best timbers.

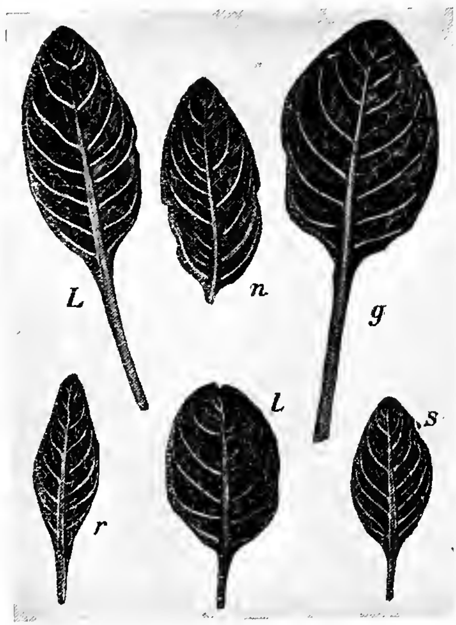
Loganberry.—The loganberry is a recent cross between the blackberry and the raspberry, which transmitted its characters true. It

was produced in 1900 by Judge Logan of the U.S.A., and Luther Burbank of California has made thousands of such crosses.

The Rose.—In the words of Darwin :—

> " Whenever a rose appears with any peculiar character, however produced, if it yields seed Mr Rivers fully expects it to become the parent type of the new family."

Fig. 191.—The lowberry, another hybrid fruit, larger and blacker than the loganberry and less acid to the taste; half natural size.



(*After Hugo de Vries.*)

Fig. 192.—Leaves of the evening primrose, showing varieties.

The Evening Primrose.—Hugo de Vries found a number of roots of an American plant of the evening primrose in a potato field near the town of Hilversum, by Amsterdam, in Holland. He cultivated and examined some 50,000 individuals of them. He discovered a number of forms which had never been catalogued in any of the botanical books, and found these new forms, to which he attached new names, flowered true to type and kept their own character. " Greater deviations than the ordinary may be attained by sowing very large numbers and by selecting from among them the extreme individuals and sowing anew from their seed."

The Pea.—The Austrian peasant and monk Gregor Mendel was the first to conduct an exact numerical inquiry into the effects of crossing various types of the common pea. Thus he crossed tall peas 6 to 7 feet long (T) with dwarf peas (D) $\frac{3}{4}$ to $1\frac{1}{4}$ feet long (parents). The cross-breed was a tall one, so he called the tall character "dominant," the dwarf character "recessive." These tall cross-breeds (children) were then allowed to fertilise themselves; the

(*After Walter Bateson, Cambridge University Press.*)

FIG. 193.—Gregor Mendel

grandchildren were mixed roughly in the proportion of three tall to one dwarf. Mendel found these dwarf forms bred onwards pure dwarfs. A varying percentage of the tall forms also bred on as pure talls Thus the peas were found diverging in cultivation along definite lines, some of which maintained the original form even after crossing

The Bean.—W. Johannsen of Denmark weighed the seeds of the kidney-bean, estimated the average value, and the difference of each from that average-value. Some plants were nearer the average-value of the whole race, others more distinct. He isolated some of these plant types, allowed each type to propagate by self-fertilisation,

and found each plant line had an average-value of its own. The units of each new line lay around a new average-value. He called the separate lines "pure lines," each showing a tendency already noted by Charles Darwin: "The tendency in each part or organ to go on varying in the same manner in which it has already varied."

Bud Variations.—Darwin notes it is "a singular and inexplicable fact that when plants vary by buds the variations, though

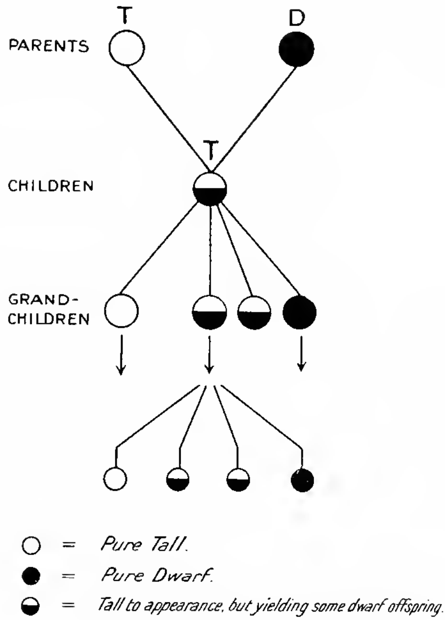


Fig. 194.—Mendel's crossing of the pea.

they occur with comparative variety are often, or even generally, strongly pronounced"; and again, "it deserves notice that all the plants which have yielded bud variations have likewise varied greatly by seed."

He enlarges upon this as follows:—

> "Mr Salter remarks, 'Everyone knows that the chief difficulty is in breaking through the original form and colour of the species, and every one will be on the lookout for any natural sport, either from seed or branch; that being once obtained, however trifling the change may be, the result depends upon himself.'"

M. de Tonghe, who has had so much success in raising new varieties of pears and strawberries, remarks with respect to the former :—

> "There is another principle, namely, that the more a type has entered into a state of variation, the greater is its tendency to continue doing so; and the more it has varied from the original type, the more it is disposed to vary still further. . . . The most celebrated horticulturist in France, namely, Vilmorin, even maintains that, when any particular variation is desired, the first step is to get the plant to vary in any manner whatever, and to go on selecting the most variable individuals, even though they vary in the wrong direction; for the fixed character of the species being once broken, the desired variation will, sooner or later, appear."

(*After Charles Darwin.*)

FIG. 195.—Hamburg fowl.

The Peculiar Case of the Hamburg Hen.—To quote Darwin again :—

> "A good observer (Mr Williams) states that a first-class silver-spangled Hamburgh hen gradually lost the most characteristic qualities of the breed, for the black lacing to her feathers disappeared, and her legs changed from the leaden blue to white; but what makes the case remarkable is, that this tendency ran in the blood, for her sister changed in a similar but less strongly marked manner; and chickens produced from this latter hen were at first almost pure white, but on moulting acquired black colours and some spangled feathers with almost obliterated markings, so that a new variety arose in this singular manner."

Here we see an extreme change holding its own.

Selection in Breeding.—For that matter there is not a breeder in the country who is not working on the retention of differences in this way. Tollet, after eight years of selection from good milking cows and bulls descended from good milkers, managed to increase the product of the milk in the proportion of four to three. This is only done in the belief that such change will hold good. Careful selection

of the silkworm in France during sixty-five generations lessened the proportion of yellow cocoons, which do not resist the fungus as well as the white ones, from 100 to 35 in the 1000. A ram-lamb was born on the Mauchamp farm in 1828 characterised by specially long and silky wool. The breed has bred true, and the wool sells at 25 per cent. above the best merino wool.

Sometimes—as in the case of the monstrous creatures which once prowled our globe—the new line was so extreme as to end in the complete disappearance of the line.

Nature sometimes refuses to be driven along a new line. In the artificial selection of beets to yield a higher percentage of sugar, according to de Vries, " A lasting influence has not been exercised, but the improvement is still as dependent upon continuous selection as it was half a century ago."

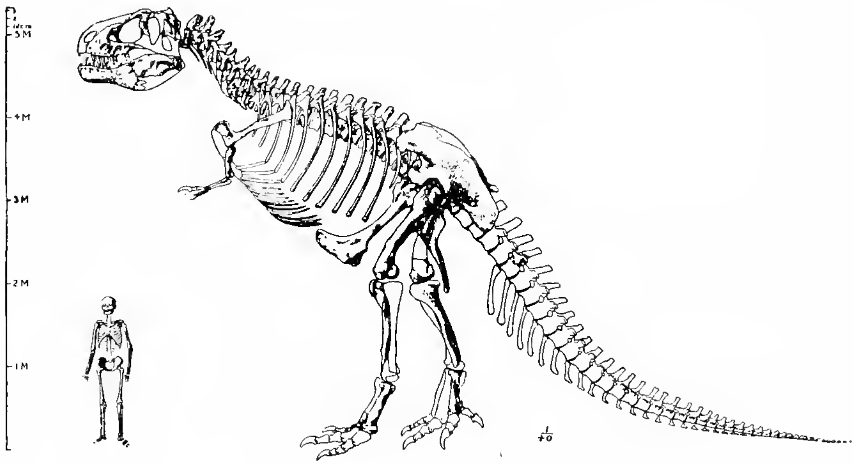
Nevertheless new forms can hold firm, and their holding steady is not explained by Natural Selection.

So we have these three difficulties against natural or external selection :—

1. The form-environment discord.
2. The origin of form.
3 The retention of form.

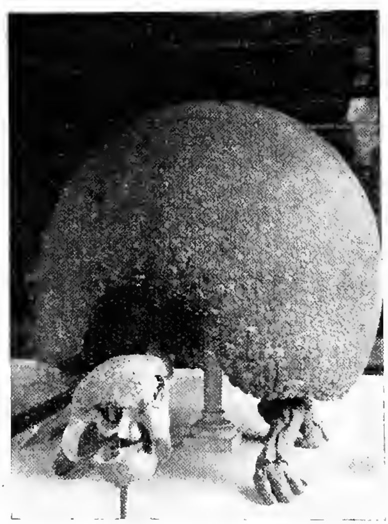
They justify the following admissions by Charles Darwin and August Weismann themselves, as given in their own words :—

> " Instances could be given of similar varieties being produced from the same species under external conditions of life as different as can well be conceived ; and, on the other hand, of dissimilar varieties being produced under apparently the same external conditions. Again, innumerable instances are known to every naturalist of species keeping true, or not varying at all, although living under the most opposite climates. Such considerations as these incline me to lay less weight on the direct action of the surrounding conditions than on a tendency to vary, due to causes of which we are quite ignorant " (Darwin).
>
> " I am convinced that natural selection has been the most important but not the exclusive means of modification " (Darwin).
>
> " The nature of the conditions is of subordinate importance in comparison with the nature of the organism in determin-



(*After H. F. Osborn of New York.*)

FIG. 196.—Tyrannosaurus; a prehistoric monster which doubtless upset the nerves of our ancestors.



(*Photo. by J. H. Leonard.*)

FIG. 197.—Giant armadillo: South Kensington Department of Natural History.

Shell length, $6\frac{1}{2}$ feet; breadth, $3\frac{3}{4}$ feet; height, $3\frac{1}{2}$ feet; and along the curves 7 feet long by 9 feet across.

ing each particular form of variation; perhaps of not more importance than the nature of the spark by which a mass of combustible matter is ignited has in determining the nature of the flames" (Darwin).

"Selection is the paramount power, yet its action absolutely depends on what we in our ignorance call spontaneous or accidental variability" (Darwin).

"Selection does not call forth the unusual variation, but simply works upon it—the kernel of the riddle lies in the varying" (Weismann).

Why is every bluebell different from the next? Why? Why?

FOURTH STEP.

DIFFERENCE.

Look up. See that rock, that tree, that sheep. We grasp them by our hands, our eyes and ears. We think to comprehend them. But you and I are not standing just at the same point. So how

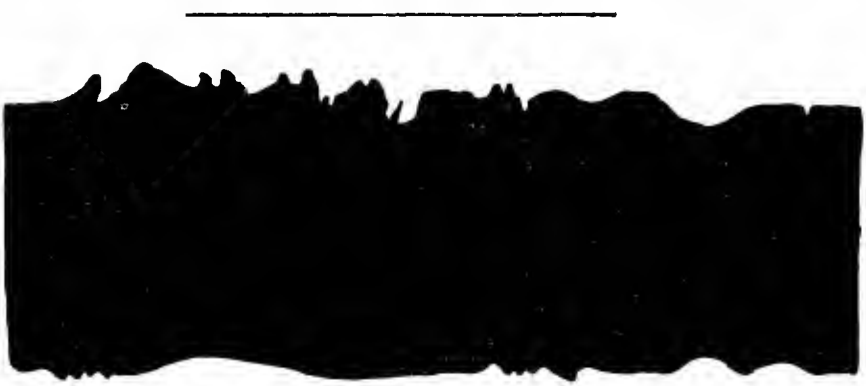


Fig. 198.—A straight line, and part of the same line magnified by the microscope.

can you and I come to any truth of these things when we see differently. Do not our senses play us false? If they are unfaithful in a few things, can they become master of many things? Draw a line upon paper; you think it straight, but with a powerful glass its edge appears torn and jagged like the edge of a saw. The hills

opposite seem near at one time and far at another, though the distance remains actual. You were a child once—was not the school playground much bigger then? Where is the measure of reality? Are these things but the images of our minds? Are they unreal?

No, the thrashing we received as a boy was real enough. Because we are prone to nurse optical illusions, we dare not argue that matter is not real. For we are not the slaves of our senses, we can rely also on instinct and reason and calculation; for instance, we can, if we will, measure the above optical illusion and find it false. An infant forms a view of its mother when it first opens its eyes upon her, but it does not see her, for it fails to recognise her again, often much to the mother's annoyance; it has to look once, twice,

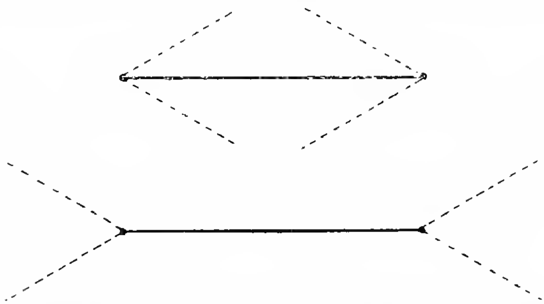


Fig. 199.—An optical illusion or eye deceit. Both lines are of identical length.

thrice, and repeatedly before it builds up its views into a recognition of her. And just as a child clambers on its sensations of its mother to understand her, so we proceed from our views of external things to reason out differences between these things. And if there be a large enough number of people, and the average man or woman of them, after seeing and sizing up two things, concludes a difference to exist between them—for instance, between a skein of red wool and a skein of black wool—then we affirm the difference to be real and just. Some people are as colour-blind as a photographic plate, and cannot distinguish red as red, or black as black.

Yet the average view is the right one. And if we are to think at all, we have to take the following as true in practice:—

> "*Average differences in human sight of external things suggest real differences within these things.*"

The miner coming off his eight-hour shift recognises the reality of dust. Let us seek to begin life also at the face.

FIFTH STEP.

THE FLUIDITY OF TISSUE.

This is admittedly an assertion, which it is proposed not to defend.

Suffice to remark it was based on observation of a series of tissues from the following :—

> Frog, salamander, young crocodile, parrot, bat, hedgehog, ichneumon, rat, wallaby, cat, puppy, dog-faced monkey, mandrill; children from under one year up to fourteen years, and adult men and women.

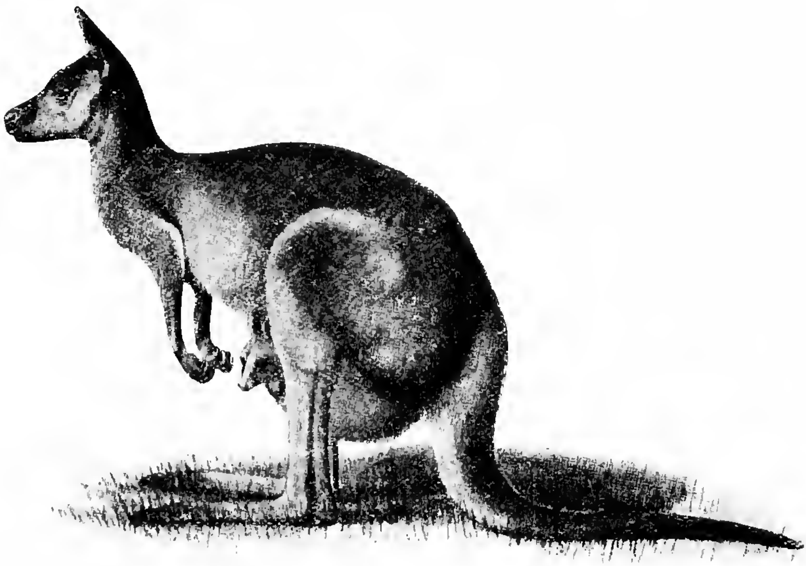
(*After John Gould.*)

FIG. 200.—The wallaby of Australia.

But you see that mother with her little hefty fellow hanging at her skirts. You notice its legs are bent and bandy, like a croquet-hoop. Under its weight its bones have yielded. Or to put the point another way, they have diverted from the natural shape into a curved and crooked shape, as jelly moulds itself to the form of a can. Bones are just soft tissues stiffened up with lime, and on their first appearance in the infant are easily bendable, like putty

or modelling clay ; the bones are fixed with lime just as a photograph is fixed with " hypo."

Bones change according to the exercise they get. If you ever had teeth extracted and a dental plate fitted you will know how the jaw changes its shape after extraction of the teeth. The Chinese were wont to bandage the feet of their growing girls tightly, and the bones moulded themselves together and became cramped



(*After William Leche.*)

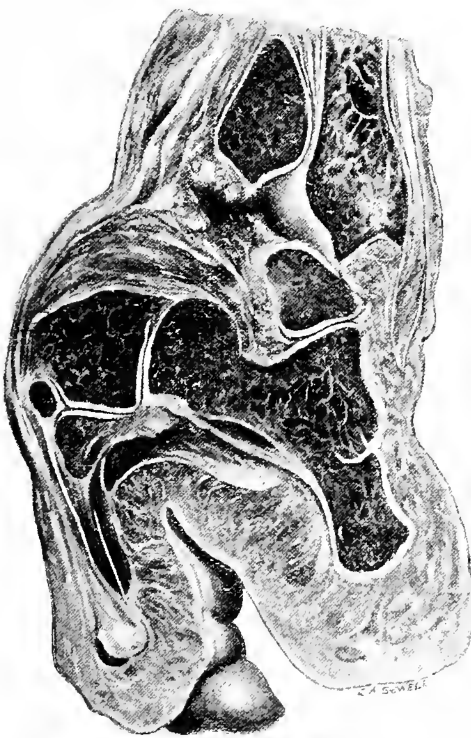
FIG. 201.—A marsupial—the kangaroo—with a youngster in its pouch.

and dwarfed and deformed in consequence ; a condition not wholly absent from our modern society.

The Frenchman Sedillot cut out part of the shin-bone from the leg of a young dog, and found afterwards that the splint-bone, which is usually only a fifth or a sixth the thickness of the other, had enlarged to bear the unwonted weight until it became as thick as the shin-bone would have been if it had been left in place. And as early as 1739 Duhamel found that when a silver ring is tied round a young growing bone it gets covered in, just as the wire of a fence gets overgrown by a tree, and finally comes to lie loose in the marrow cavity.

(*After Ploss.*)

Fig. 202.—Foot of a Chinese woman.



(*By permission of Arthur Keith, from the Royal College of Surgeons, London. Drawn by Sidney Sewell.*)

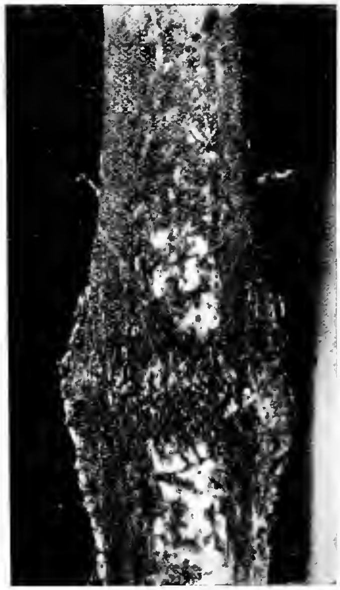
Fig. 203.—Illustrating the plasticity of bone.
Section of Chinawoman's foot, actual size, showing crushed bones.

In the thigh bone of a man (shown in fig. 204), we see the two ends of the bone have healed and glued together, after one

(*Hunterian.*)

Fig. 204.—The fluidity of bone.

A badly-healed break near the middle of the thigh bone.



(*Hunterian.*)

Fig. 205.—The fluidity of bone.

A healing cross-break of the splint-bone. See how the bone has sealed up the shaft outside and in.

end had ridden over the other, by the bone melting and fusing the two ends together as well as it could.

But if bone be a flowing thing, still more so are our muscles. Glance at the figure illustrating the muscles of the front of the upper arm, with the biceps in front but gradually flowing off on

(*By A. K. Maxwell.*)

Fig 206.—The biceps of a man's left arm flowing continuously into the surrounding tissues.

each side into the surrounding tissues. It is a left arm, and the two tendons of the biceps are seen running upwards side by side.

Perhaps the illustration will succeed better than screeds of explanation to show what the fluidity of tissue means.

SIXTH STEP.

CONTINUOUS ONENESS OF NATURE AND MAN

Oneness.

Is not the sea gloriously one and continuous? A liner at sea seven miles away across the Firth of Clyde—a heave from ship to shore—a wave falls and drenches our feet. Has that wave travelled those seven miles? No, but rather a heave upon a continuous water.

Michael Faraday sprinkled iron filings on a card, held it over a magnet, and the filings fell into definite lines, though they were

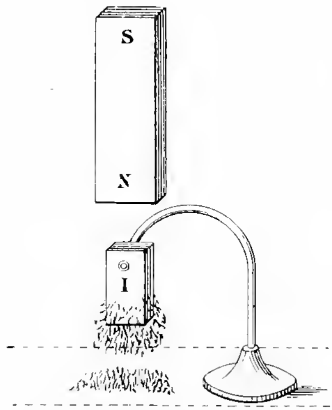


Fig. 207.—A magnet inducing a block of soft iron to attract iron filings to it through "space."

separated from the magnet by the card. The magnet speaks through space to the filings. The magnet and the filings are continuous.

Or one ship signals to another without a wire.

Or the Italian Giulio Ulivi succeeds in exploding chemicals sunk in the bed of the river Arno "by wireless" from a tower in Florence.

And there are many more.

The same in man. Man is not a house built of bricks joined by connecting cement, but like the ivy growing on its wall. He is not a system of seven distinct separate parts: skin, muscle, bone, nerve, blood, digestive-tissue, gland-tissue.

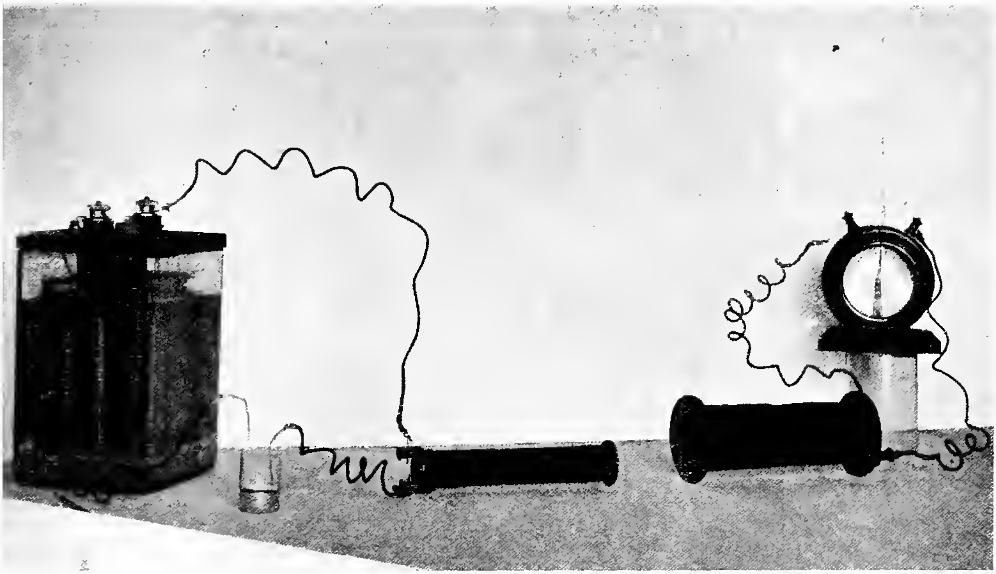


Fig. 208.—Continuity.

C = Cell.
MC = Mercury cup.
PC = Primary coil (say Britain).
SC = Second coil (say America).
G = Galvanometer.

As long as the primary circuit, on left, is complete, the needle of the second circuit stays steady. But each time you lift a wire out of the mercury the second circuit or circulation jerks, with a momentary deflection of the magnetic needle.

In this the impulse travels only a short way, from PC to SC. But Marconi wirelesses from Britain to America, and the sun wirelesses its light daily to earth over ninety million miles, which again is a short span to the distance from earth to the great sun Sirius.

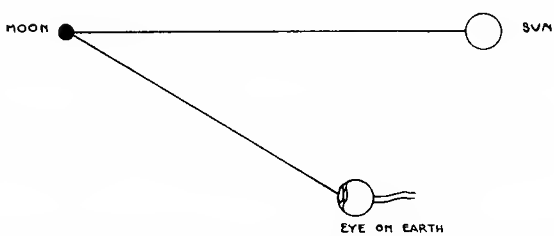


Fig. 209.—The continuity of the heavens: sun to moon to earth.

He is rather like the rainbow: red, orange, yellow, green, blue,

(After J. Graham Kerr, in the "Proceedings of the Royal Society of Edinburgh.")

FIG. 210.—Illustrating continuity.

Microscopic section of young lung-fish, *Lepidosiren*. The early spinal cord (*s.c.*) and the early muscle (*m.*) are seen withdrawing apart, leaving a communication or nerve (*n.*) between them.

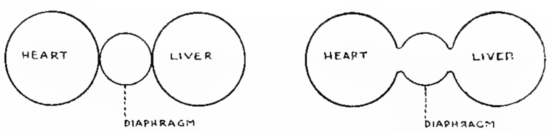


FIG. 211.—The human body: discontinuity *v.* continuity.

indigo, violet, each part and colour distinct in itself, each part and colour blending into, running into, becoming, the next one.

SEVENTH STEP.

DEFINITION.

How far are we come?

After alluding to the *spirit* in which inquiry may be undertaken, we note briefly the *way* to search. Then we refer to the *need* of opening inquiry into the foundations of modern belief, the theory of Atoms, and Charles Darwin's theory of Natural Selection. We there discover that things are *different* from each other. And after investigation of some points of difference in animals and man, the details of which are not stated herein, it is concluded that tissue is a *solid-fluid* akin to water. We also deduce that tissue, like water, is of a *continuous* substance in character.

Let us now proceed to a still closer inquiry into the quality of difference in Nature. And before entering upon an observation of certain facts evident in man, let us first consider and illustrate the terms we may usefully employ.

Words are set labels. Snares! Nets! Webs to enmesh unwary flies. Yet withal, as Epictetus the Greek observes :—

> "Unless we shall first establish what is a measure and what is a balance, how shall we be able to measure or weigh anything?"

The gardener does not delve with his hands.

Simple Words.

Firstly, then, a "difference" is not identical with a "change."

A Difference is a difference.

A Change is a change.

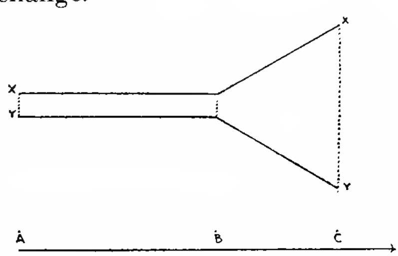


Fig. 212.—Illustrating Change and Difference of a plant's growth (XY) in time (AC).

For see, that seedling changes into a plant; there is a difference between the condition "seedling" and the condition "plant." In

this figure—let the stalk growing from the period A begin to sprout into leaves at the point B in time, so that at the point C in time a difference from B is become apparent. But the degree of spread of the leaves in the plant at C is the measure not of the ability of the plant to change at C, but of its previous capacity to change at B, or even earlier; between A and B "seedling" differs from "plant," "seedling" changes *into* "plant." Such is obvious, but the obvious things, the thing right under our noses, we miss often.

Or take the Cotton—Mill—Shirt.

The shirt follows on changes within the mill, and so at last becomes other and different from the raw material, the cotton.

Let us proceed to some aspects of difference in man. Take one hundred men and women and measure their height of stature. Assuming the hundred you select to range from 5 feet 4 inches to 6 feet 2 inches, you can divide them into five set classes :—

(1)	5	feet	4	inches	to	5	feet	6	inches.
(2)	5	,,	6	,,	,,	5	,,	8	,,
(3)	5	,,	8	,,	,,	5	,,	10	,,
(4)	5	,,	10	,,	,,	6	,,		
(5)	6	,,		,,	,,	6	,,	2	,,

The middle group (3) contains the largest number of people, the end groups (1) and (5), with the shortest and tallest, contain fewer numbers. You can, if you like, plot this on paper to the eye by

FIG. 213.—The reader may here pencil in a diagram of five columns, each representing his idea of the heights of 100 men—ranging in height from 5 feet 4 inches to 6 feet 2 inches.

drawing a base line in five equal parts and representing the number of men by erect columns thereon.

Connect up the upper corners of the columns, and you may secure a fan-shaped curve.

A man or a woman grows from infancy to stature either within such a centre column or within such an end column. Words are

meagre things, but on the whole man takes the bent either towards the centre or towards the end. For the moment let us call these two bents *Hold* and *Divergence.* He of 5 feet 9 inches illustrates Hold, they of 5 feet 4 inches and 6 feet 2 inches illustrate Divergence.

A few more instances culled from element and plant and animal may be added.

Hold.

1. On the stature of a large number of fathers and sons being measured, it was found that fathers averaging 72 inches in height had sons of an average stature of 70·8 inches, while fathers with an average height of 66 inches gave sons averaging 68·3 inches. This tendency towards an average value is a Hold towards the average or middle.

2. Grains of corn coming from the mummy-cases in the Pyramids have sprouted on being sown—this after being dried for thousands of years. The eggs of the water-flea have been kept in dry mud for ten years, and have been found alive at the end of it. A similar high degree of Hold may also be seen in man; thus a man has walked half a mile and lived ten hours after having fractured his skull, broken ten ribs, and burst open his spleen and kidney in a fall.

3. Or again, the Adam's laburnum blossoms at one part of the tree into yellow flowers like the common laburnum, at another into purple flowers like the purple laburnum; one half of a bunch may be yellow and the other half purple; and Charles Darwin even observed a single flower divided into halves, one side bright yellow and the other purple. Hold of character to a high degree may also be seen in experimental work. Winckler grafted the nightshade (*Solanum nigrum*) on to the tomato (*Solanum lycopersicum*), and from some of the fusion surfaces obtained shoots that bore the dark green leaves of the nightshade on the one side and the light green tomato leaves upon the other (fig. 214). Each plant kept its own quality.

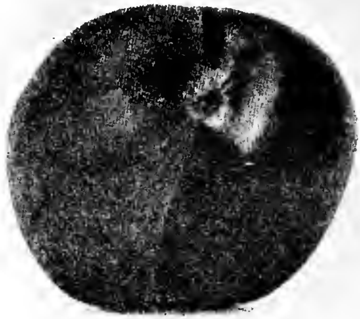
Fig. 216 represents four young rats, all of one litter, bred from parents (1) pure white, (2) black and white. Here we see a Hold along these two definite lines, two being pure albino with pink eyes, and two being black and white with jet black eyes. One litter. Hereditary Hold to type is remarked upon by Charles Darwin :—

> "I may give one other instance on the authority of Mr R. Walker, a large cattle-breeder in Kincardineshire. He bought

a black bull the son of a black cow with white legs, white belly,

(*After C. Winckler and Oscar Hertwig.*)

Fig. 214.—Fusion-grafting of nightshade and tomato.



(*After Burbank, Jordan, and Kellogg.*)

Fig. 215.—Hold in case of apple ; one half bright red and sour, other half greenish-yellow and sweet ; note the sharp line between them.

(*Photo by S. Fingland, Glasgow.*)

Fig. 216.—A single litter of young rats : two albino eyed, two jet eyed.

and part of the tail white, and in 1870 a calf, the gr.-gr.-gr.-gr.-grandchild of this cow, was born coloured in the same

(*After Robert Wallace of the Scottish Agricultural College, "British Live Stock."*)

FIG. 217.—Wild cattle in Chillingham Park, Northumberland.

(*After Robert Wallace. Photo by C. F. L. Gillingham.*)

FIG. 218.—Wild cattle in Chartley Park, Staffordshire: bull and cow.

very peculiar manner, all the intermediate offspring having been black."

The famous white wild cattle of Chillingham, in Northumberland, are said not to have varied much since the thirteenth century.

Hold may occur even within one individual; thus a bullfinch has been described, one half male holding the red feathers of the cock, the other half female with the brown feathers of the hen.

Hereditary Hold is seen also in mankind. The child loses its milk teeth as did its parents. Like twins may bear such a close resemblance to each other both in form and mental constitution that even their handwriting is alike. Tendencies to consumption and mental instability run in families. In several individuals of one human family two pits were found on the lower lip, this condition being inherited and in every case associated with cleft palate. Again, the woman is generally credited with more of Hold than Divergence; hare-lip, cleft palate, club-foot, extra fingers, colour-blindness, bleeder's disease being stated to be commoner in the male.

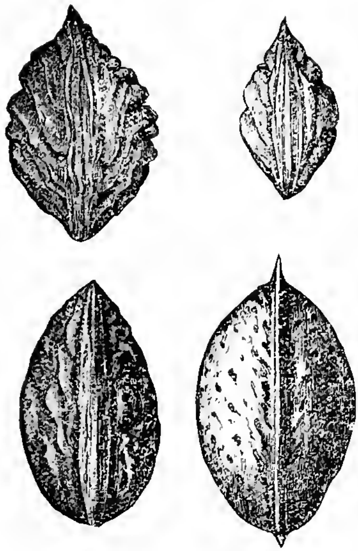
4. Fountain pens are often tipped with iridium, because that metal is peculiarly hard. It forms one of three metals very similar in character, called osmium, iridium, and platinum. For one thing, they do not fuse readily. When iron boils in the furnace like water, platinum remains like Shadrach, Meschech, and Abednego, apparently unscathed. Referring back to the list of elements on page 8, we observe their comparative weights as :—

Osmium	191
Iridium	193
Platinum	195

Here we observe three different elements to manifest a close degree of " Hold " in respect of weight.

Divergence.

1. A purple plum suddenly bears yellow fruit. A nectarine suddenly appears on a peach tree, which has never, so far as known, borne nectarines before. The peach is said to be the modified descent of the almond. A double-flowered almond is cited as producing almonds for some years, then suddenly bearing for two years in succession spherical fleshy peach-like fruits, finally producing large almonds again. Or the gall insect introduces a minute drop of the secreted poison into the leaf of the oak or willow, and forthwith the

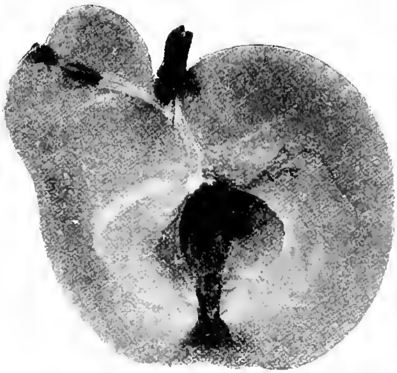


(*After Charles Darwin.*)

FIG. 219.—Peach stones (above) and almond stones (below).

(*After Percy Groom.*)

FIG. 220.—Oak spangle-galls.



(*Natural History Department, South Kensington.*)

Fig. 221.—Divergence in apple: Natural History Department, South Kensington.

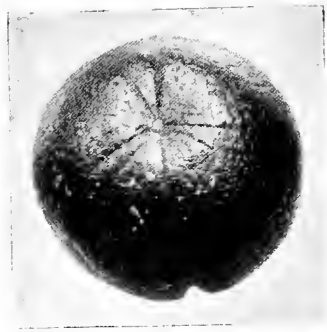


Fig. 222.—Divergence in orange: the markings of the liths affect even the skin.

(*Natural History Department, South Kensington.*)

Fig. 223.—Divergence in mouse.

(*After Walter Bateson.*)

Fig. 224.—Rhythmical Divergence in tusk of Indian elephant.

plant tissue diverges into the form of a gall, a little hard berry upon the leaf. Or a mouse may grow a horn.

Such a Divergence may be regular or in orderly sequence; instance the sequence of rings on an elephant's tusk.

(*By the courtesy of James Wilson of the Veterinary College, Dublin.*)

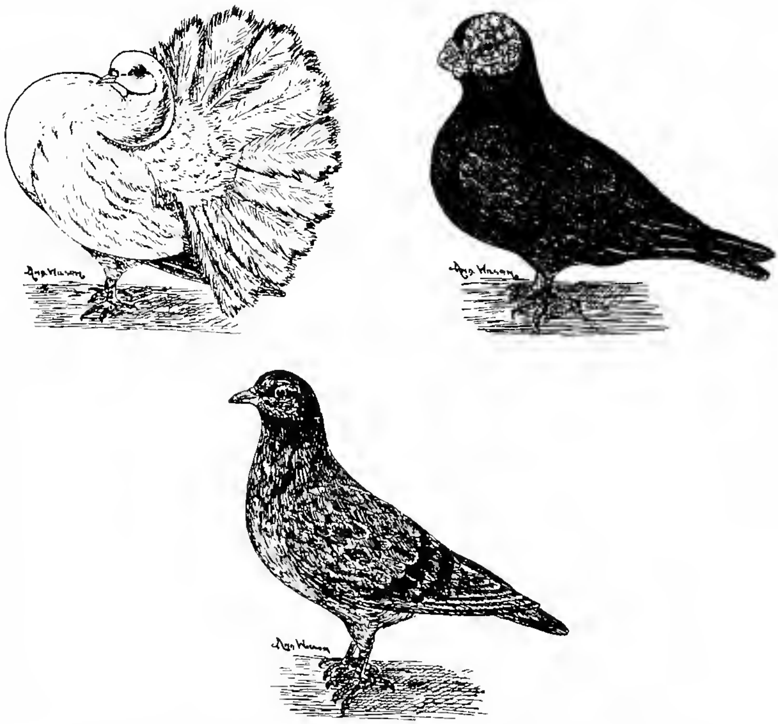
FIG. 225.—Monstrous calf of the Dexter-Kerry breed.

(*After James F. Gemmill, University of Glasgow.*)

FIG. 226.—A sea-trout Siamese twin.

2. Monstrosity is but a further Divergence. Thus a fish may have extra fins or an extra tail; a hare such long front teeth that it cannot nibble. A child may be born without a brain or with extra fingers. The united Siamese twins were but one of many sports or freaks.

3. Divergence on crossing. Instance, the classical case in pigeons by Darwin. He crossed a mongrel barb-fantail (black pigeon × white pigeon) with a mongrel barb-spot (black pigeon × white and red pigeon), and the upshot was " a bird of as beautiful a blue colour,



(*By Andrew Wilson.*

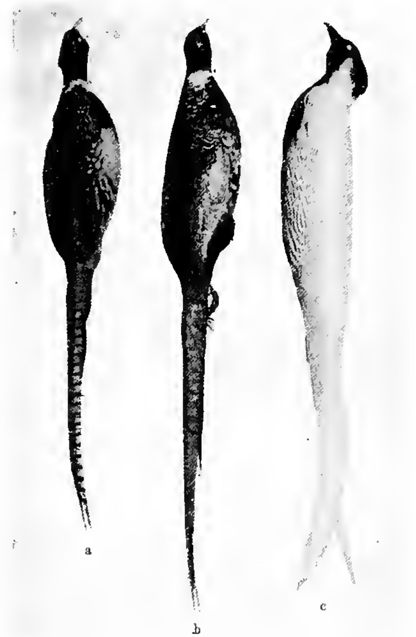
FIGS. 227, 228, 229.—Fantail, barb, and common rock pigeons.

with the white loins, double black wing-bar, and barred and white-edged tail-feathers as any wild rock pigeon." * On the contrary,

* Amplified in *Animals and Plants,* vol. ii. p. 200:—"I paired a mongrel female barb-fantail with a mongrel male barb-spot; neither of which mongrels had the least blue about them. Let it be remembered that blue barbs are excessively rare; that spots, as has been already stated, were perfectly characterised in the year 1676, and bred perfectly true; this likewise is the case with white fantails, so much so that I have never heard of white fantails throwing any other colour. Nevertheless the offspring from the above two mongrels was of exactly the same blue tint as that of the wild rock pigeon from the Shetland Islands over the whole back and wings; the double black wing-bars were equally conspicuous."

Divergence on crossing may show itself as a blending of two parent types to give an intermediate form; compare the cross figured between the ring-pheasant and the silver-pheasant.

4. The elements chlorine, bromine, and iodine—the first a yellow gas, the second a brown liquid, the third a purple solid—are strik-



(*After Baur.*)

FIG. 230.—Ring-pheasant, silver-pheasant, and cross (in middle).

ingly similar in chemical character. Yet their estimated weights are very different:—

Chlorine	35·5
Bromine	80·0
Iodine	127·0

Here we have allied elements manifesting a high degree of Divergence in respect of weight: the Divergence is very equal in this case, for if we take the sum of chlorine and iodine, 162, and divide by 2, the result is 81, which is very near the actual weight of bromine.

These two terms, Hold and Divergence, possess no absolute worth.

A weak Hold and a mild Divergence are much the same. But the terms are handy. For example, if a growing plant be kept constantly agitated by keeping it on the move, its growth is first retarded, but afterwards accelerated. Here we have (1) a Hold, (2) a Divergence.

Or again, if eggs of the sea-urchin be treated with water free of lime, or with water containing salts of soda, potash, and magnesia,

(*After Jacques Loeb.*)

Fig. 231.—Twin formation in the sea-urchin.

In dilute sea-water the fertilised egg bursts, and a part of the contents flows out.

they tend to give rise to twins. But they can still be induced, just when they are splitting into two, to heal up completely and develop into a single sea-urchin. This is conveniently described as (1) a Hold, (2) a Divergence.

And in the case of even such an elemental body as water, it *holds* just before it *diverges* into steam. Spill a few drops from your breakfast cup on to that modern superfluity, the aluminium heating-plate. The drops immediately roll themselves into little round balls, and run around on the plate just like quicksilver, till they gradually sizzle away into steam.

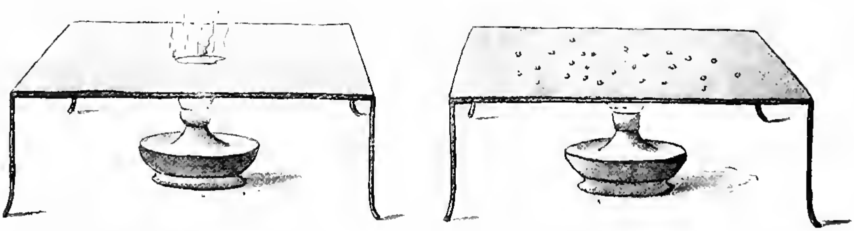


Fig. 232.—Divergence and Hold in the case of water on an aluminium plate.

(1) To steam on the warm plate.
(2) To water balls on the hot plate.

You may object: These two terms, Hold and Divergence, are of too general a nature. Cannot they be expressed by way of numbers?

Yes, that can be attempted, although it is not really possible

to state an idea in numerals. Numbers are useful in the estimation of differences, and some men and women are partial to them for the sake of clearness.

To proceed numerically, therefore. Let us weigh ten hen's eggs, using the decimal system, as it is the easiest to work.

> The metre measures a little over 3 feet $3\frac{1}{3}$ inches, and contains 10 decimetres, 100 centimetres, and 1000 millimetres.
>
> The litre = a cube of $\frac{1}{10}$ metre.
>
> The gram = $\frac{1}{1000}$ of the weight of a litre of water taken at a set temperature and set atmospheric pressure.
>
> 1 gram = $15\frac{2}{5}$ grains of English weight.
>
> 1 kilogram = $2\frac{1}{5}$ pounds ,, ,,
>
> 1 litre = $1\frac{3}{4}$ pints ,, ,,

Well, then, the weights of our ten eggs are: 60 grams, 61 grams, 62 grams, 63 grams, 64 grams, 65 grams, 66 grams, 67 grams, 68 grams, and 69 grams. Each egg differs from the next one of the series by the figure one.

Fig. 233.—A hen's egg.

Often it is the average-figure which is taken to estimate the degree of difference; in the series 2, 4, 6, 8, 10, the figures 2 and 10 are each separated from the average-figure 6 by a difference of 4. The average is obtained by summing up all the figures of a series of units and dividing by the number of units. In the case of our eggs this works out at $\frac{645}{10}=64{\cdot}5$. To find the difference in weight of each egg from this the average-figure—a "mean" it is often called—we subtract 64·5 from each number in the series and secure the following: 4·5, 3·5, 2·5, 1·5, ·5, ·5, 1·5, 2·5, 3·5, 4·5. Adding up these numbers gives a total difference-number of 25. Divide this by the number of units, 10, and we express the total difference in terms of the number of units. In this series $\frac{25}{10}=2{\cdot}5$; this may be stated as the difference-figure for the weights of this series of ten hen's eggs.

Now take another series altogether, the length of ten mealworms, as in fig. 234, thus: 22 millimetres, 23 mm., 24 mm., 25 mm.,

26 mm., 27 mm., 28 mm., 29 mm., 30 mm., 31 mm. The average-figure in this case is 26·5. Here also, as in the ten eggs, the total difference from the average is 25, and as there are ten units, the expression of the total difference in terms of the units also amounts to $\frac{25}{10}=2{\cdot}5$.

But it strikes us at once that as the average-figure was 64·5 in the egg series and 26·5 in the mealworm series, the difference in the

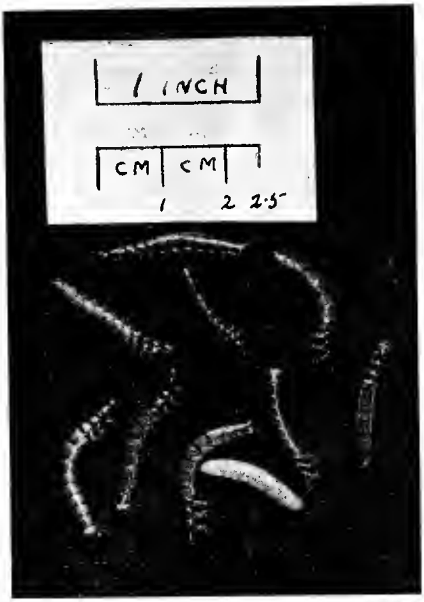


FIG. 234.—The inch, the centimetre, and the mealworm.

mealworm series is really greater than in the egg series; in other words, $\frac{1}{26{\cdot}5}$ is greater than $\frac{1}{64{\cdot}5}$. The question at once arises, How can we compare the difference of the egg series with that of the mealworm series?

If two pendulums are each swinging at the same distance, the shorter will be really swinging out farther than the larger one; and clearly, to estimate the real swing of each from the mid-line, we must take account of the length of each pendulum. Similarly, in estimating the difference or spread of a series from the average-figure we have to take account of the size of the average-figure. So to compare the difference of the egg series with that of the mealworm

series, we shall express in each case the average difference from the mean-figure in terms of the mean-figure, thus :—

$$\frac{2{\cdot}5}{64{\cdot}5} \text{ in the egg series,}$$

and $$\frac{2{\cdot}5}{26{\cdot}5} \text{ in the mealworm series,}$$

and by multiplying by 100 we can now reduce these two quantities to common percentage terms; thus :—

$$\frac{2{\cdot}5}{64{\cdot}5} \times 100 = {\cdot}39$$

$$\frac{2{\cdot}5}{26{\cdot}5} \times 100 = {\cdot}94.$$

In other words, the final difference-figure for the lengths of the mealworms works out more than double that for the weights of the eggs.

Thus the difference-figure of one series, in respect of the quality of eight, can be compared with the difference-figure in respect of the quality of length, by stating the total difference of each series in terms of the average-figure of that series. Other series can also be compared. Of course 10 units are far too few on which to determine a figure of difference; 100 units would be better; 1000 units still better; and so on. But we need not worry about that for the moment when we are entering only on the principle involved.

Difference-figures can be represented pictorially. In one series of 200 hen's eggs the weights were found to range from 48 grams to 76 grams, as follows :—

48 : 1	58 : 16	68 : 7
49 : 0	59 : 18	69 : 4
50 : 1	60 : 14	70 : 1
51 : 5	61 : 22	71 : 1
52 : 3	62 : 9	72 : 2
53 : 3	63 : 21	73 : 1
54 : 7	64 : 14	74 : 3
55 : 10	65 : 11	75 : 0
56 : 5	66 : 8	76 : 1
57 : 7	67 : 5	

These results can be plotted out on a diagram by marking the weights of the eggs along a base line, and the number of units to

each weight as uprights from that base line. There is only one egg of 48 grams and twenty-two eggs of 61 grams, so the sixty-one upright would be twenty-two times the height of the forty-eight upright. In this series there are irregularities; thus between the twenty-two units of 61 grams and the twenty-one of 63 grams there

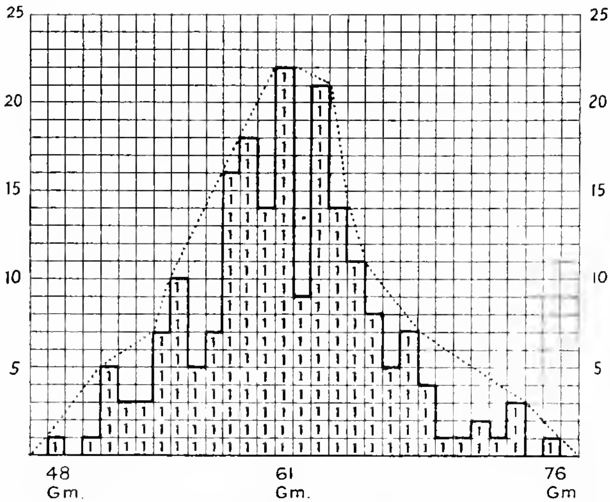


FIG. 235.—Pictorial representation of weights of 200 hen's eggs, connected up to form a curve.

is a drop to only nine units of 62 grams. But assuming that 2000 eggs had been weighed instead of 200, we might reasonably reckon on the uprights rising fairly evenly, so that when their tops were connected up, the connecting line would be roughly a curve; even

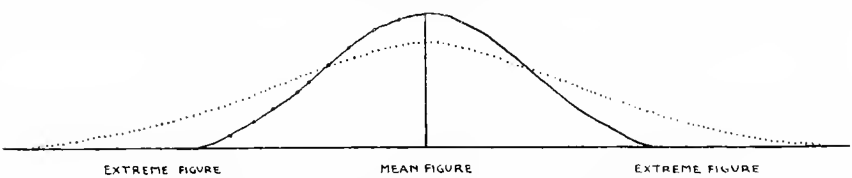


FIG. 236.—Two symmetrical curves of different spread.

though there are still some irregularities, the number of the eggs to each weight would fall around a fairly symmetrical curve; in other words, the spread to each side of the mean-figure would be, roughly, equal, as in fig. 236. In the 200 hen's eggs there are ninety units under 61 grams and eighty-eight units over 61 grams, so that the

mean-figure in this instance would be roughly 61 grams. In the figure we see :—

1. The curve of difference or spread.
2. The mean-figure, about which most of the eggs congregate.
3. Two extreme-figures, one tailing to the *plus* side of the mean-figure, the other to the *minus* side of the same, with only a few exceptionally heavy and light eggs at each end.

A fall in the total difference or spread could be represented by a smaller spread of the curve to opposite sides of the mean-figure ;

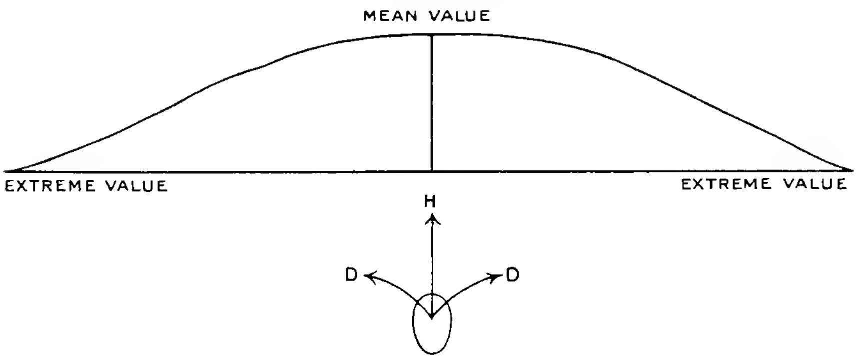


FIG. 237.—Hold and Divergence.

a rise in the total difference or spread by a greater spread of the curve to opposite sides of the mean-figure, as in the dotted line.

Without concerning ourselves as to how each of the 200 eggs arrived at their different weights, we can now proceed to analyse the meaning of Change still further. Each egg changed in one of three directions :—

1. Towards the mean-value.
2. Towards one extreme-value.
3. Towards the other extreme-value.

This change in a definite direction can be in two mean ways :—

1. If the change be towards the mean-value of a series, it is a Hold (H in the diagram).
2. If the change be towards an extreme-value, it is a Divergence (D D in the diagram).

In a Hold, the change is towards constancy of type; in a Divergence, the change is away from type.*

In a series of units, when we see a *decreased* range of difference, a smaller spread, with most of the figures clumped around the average-figure or typical unit, we infer a Hold on the part of such a series; when we see an *increased* range of difference, a larger spread, we infer a *Divergence*; thus:—

Lower difference-figure = Hold = Adherence to type.
Higher-difference-figure = Divergence = Alteration from type.

To use a simile, when a company of men is falling in from the wings towards the centre, the difference-figure works out lower—a Hold; when a company of men is extending out from the centre to right and left, the difference-figure works out higher—a Divergence. These two terms cover two main qualities in Nature and two chief types of the human mind:—

1. The hereditary and conservative tendency to hold true to type.
2. The hereditary and enterprising tendency to differ from type.

Truth pertains to both.

EIGHTH STEP.

CHANGE OF MAN.

When does man cease from changing? At what age? At one? Or at seven? Or at fourteen? Or at twenty-one? Or at twenty-eight? Or at fifty-six? Or at seventy? And is a man past his best at forty years? Man changes, but how? Here are one or two examples:—

---

* Charles Darwin foreshadowed this distinction as "Convergence" and "Divergence." Cp. *Origin of Species*, chap. iv.; *Animals and Plants under Domestication*, vol. ii. p. 235.

Tissue.	Strain.	Change to Difference.
The infant's mouth	Friction on front of gums in sucking.	Front teeth develop first.
Eye	Reading strain in children.	Defects in eyesight.
Ear	Noise of riveting in shipyards.	Thickening of drum of riveter's ear and deafness.
Heart	Strains.	Thickening, yielding, and dilatations.
Arteries	Strains.	Thickening and hardening.
Veins	Back pressure of blood.	Dilatation, thickening, and twisting (varicose veins and piles).
Canals of the groin .	Pressure of belly contents.	Rupture out of intestine.
Arm bone . .	Throwing cricket-ball.	Fracture.
Thigh muscle . .	Heavy riding.	Development of bone in thigh muscle.
Toes	Pressure.	Corns.
Tongue . .	Rubbing of jagged tooth.	Tongue-cancer.

Consider the middle column. In each instance the tissue has changed in undergoing a strain. We have thus :—

First.	*Second.*	*Third.*
Tissue.	Strain.	Difference.

Now, what is the usual view of change in these and other instances ? It may be briefly summed up in the words "Cause" and "Effect." A mineral, a plant, an animal, a man, change ever from without. The housewife drops a plate on the kitchen floor ; the fall is the "Cause," the breakage the "Effect." The alternative view of change is that change is never from without, that the external cause is not a controlling action, and that the end difference or result depends on the internal cause and inner strain.

These two views may be tabulated thus :—

1. A Cause.	1. An Action.
2. An Effect.	2. A Strain.
	3. A Result.

Strike a note on the piano with your finger ; you may call your striking finger the cause, and the note the effect ; you may

FIG. 238.—Portion of cinema film, showing a block of iron and soup-plates falling thereon.

1. Falling nearly horizontal.
2. Falling oblique.
3, 4, 5. Falling vertical.

also call your striking finger the act, the internal strain in the wire the real cause, and the note the result.

The difference at first sight is just one of words; whether Matter changes from an external cause or an internal strain would not seem to touch the bread and butter of the average individual. But that depends on whether these two views lead to the same or to different conclusions.

FIG. 239.—The riving oak.

Let us therefore follow them up resolutely.

The housewife lets fall a plate on the kitchen floor; it breaks. We generally regard the fall as the cause and the break as the effect. That was the first notion we came to, and we accepted it—which is complimentary to the intelligence of our ancestors, but not to our own. We do not think of any internal strain in the plate. Yet, on the second view, the plate under the action of the fall strains away in different directions, so that pieces fly away from each other, every substance taking its own time to break.

Or consider the relation between the oak intact and the oak riven. The lightning flash, " the cause," is said to fall and split the oak, " the effect," in actuality the flash, does not always pass from the cloud to the earth, but sometimes from the ground to the cloud ; however, we are wont to think of the splitting of the tree as being produced directly by the falling bolt. The opposing view is that the oak tears itself with exceeding rapidity into two. An electric-strain travels to the oak, setting up a strain within it ; the oak is now straining, and after the lapse of a variable length of time it may rend itself apart into two halves. The tearing is not instantaneous, *but occupies a certain time.*

Similarly, when a fireman burns his hand in some rescue, we con-

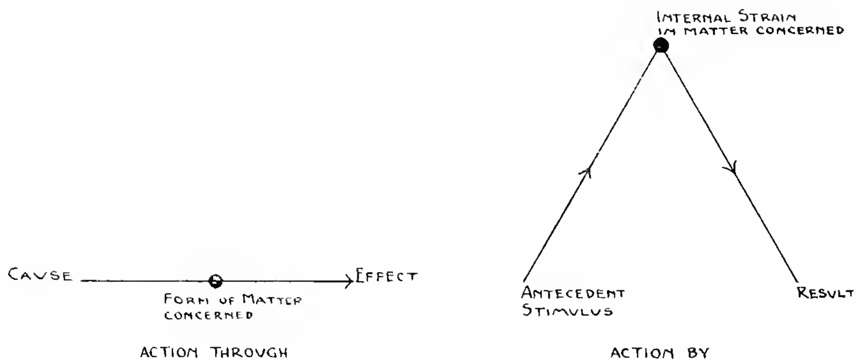


Fig. 240.—Cause *versus* Strain.

sider the fire the cause and the charring the effect. We never regard the fire as only a stimulus, the change in the hand a rapid transformation to guard against the undue heat-stimulus, and the charring the outcome of that internal change, a change *intermediate* between the " cause " and the " effect."

Here a new vision confronts us, like a picture on the gallery wall. The picture is all a blur to us, but once catch it, and we will never forget it. The above illustrations are all too feeble to aid much. So consider the figure. On the energy view, our mental gaze is directed to the first and third points, the Stimulus and the Result (usually called the Cause and the Effect). On the inner view, the first and third points sink into insignificance compared with the Internal Strain.

The second alternative seems at first sight grotesque. I fall on my arm, and its breaks ; how can I think of it breaking *itself* into

two pieces. But you do think so sometimes; thus your clubmate throws a cricket-ball extra hard, and suddenly his arm falls limp and broken by his side. Why? Because of this same inner strain. And suppose a whole generation of us had been brought up to the idea that the changes in the plate, the oak, the hand, and the bone were changes from within, we would regard the other "cause" view as an error. If one of us were to argue to such a one, "Look here! The plate would not have fallen if gravity had not pulled it; the bone in the arm did not crack of itself, because it needed the shock to do so; oaks do not go bursting all over the place of themselves," he would simply reply :—

> "Of course we all know *that*; but it is not the point. We both know there is a cause, but is it *external* or *internal*? Do you mean to tell me that the change is wholly external? Does not the matter itself strain to modify the external action every time it changes?"

Now to contrast this alternative of Strain with the previous idea of Energy. Let us cull some simple facts from Nature, leaving the reader to add more from his own experience.

1. *Mechanical-Strain.*—Watch the shore from the deck of a tourist steamer, or the banks of the Suez Canal from a liner, or even take a row along any canal. The first sign of a movement in the water is not *up* but receding *down* the bank. The boat has exercised a suction action right through the water, one form of mechanical strain. Nothing has passed from the boat to the bank.

2. *Heat-Strain.*—We prefer to stand on a cork mat after a bath rather than on a slab of marble. Why? Because cork and linoleum are warmer than tiles. But why are they warmer? The usual energy view says: Marble absorbs a greater quantity of "heat-energy" from the feet than does cork. The strain view maintains: The marble no more absorbs any "energy of heat" than the foot absorbs an "energy of cold." Marble feels colder because it is more resistant and slow to change from a cold state to a hot state, whereas cork transforms from the cold to the hot state straight away.

The Energy view: Marble and cork are sponges.

The Strain view: Marble and cork are transformers.

Another consideration forbids us speaking of a quantity of heat or energy. We have all felt how the heat-strain from a coal fire is different—it feels wetter—than that given off from a wood fire.

Now, we have no right to project a double sensation coming from two kinds of Matter and to distinguish it as a single and absolute quantity, " heat," independent of both these forms of Matter.

3. *Light-Strain.*—When we see a lightning flash, there is no actual light between the clouds and the earth—just a strain or state of tension which our eyes and brains recognise as a bright thing. For, so far as we know, no quantity of anything passes to our eyes—just a shock. That light is not energy appears also in the heating of iron; first it is dark, then it glows " red," then " yellow," then " white," according as the strain within the metal increases.

That light is but a state of strain within Matter also appears from the fact that light changes according to the kind of Matter which passes it on; thus the Frenchman Foucault found in 1850 that the velocity of light is less in water than in air.

4. *Sound-Strain.*—There is no such thing as " Sound." There is a form of earth and air strain which is interpreted by man as " sound "; he then takes his own sensation, projects it into space, and credits it with an objective existence—a pure fancy on his part. Take the telephone, for example; it is not " sound," but a strain in the copper wire that starts a strain in the vibrating telephone plate, that starts a strain in the air, that starts a strain in the membranes and fluid of the ear, and thence stimulates auditory nerve and brain.

That " sound " is really sound-strain becomes very manifest in great natural upheavals. The association of " sound " with the earthquake or strain in the vicinity of the Japanese volcano Sakura-jima was noted by Mr Archibald C. Hutchinson, missionary at Kagoshima, in the spring of 1914: " There was a terrific noise like the crack of an enormous whip, and the earth seemed to leap convulsively upwards." The sound was not a thing apart, it was a tension associated with " a terrific " tension of the earth. And with the sound of the guns carried from Belgium and France to Eastbourne and Newhaven there is also felt a tremor of the ground.

5. *Electric-Strain.*—Perhaps the idea of strain is best appreciated when we speak of electric-strain or shock. Richmann of Petrograd was attempting in 1753 to verify the then new theory of Benjamin Franklin that lightning and electric-strain were one and the same; on 6th August of that year he was observing during a thunderstorm the indications of an electrometer connected to the iron rod he had run up his house, when there came a tremendous thunderclap,

and Sokolow, his friend, who was with him in the room, saw a blue flame suddenly appear between the iron rod and the professor's head, heard a report like a pistol, and saw him stretch out dead. What had taken place appeared on questioning an English boy of twelve of fair intelligence :—

Q. Did anything pass down the rod ?
A. Something must have passed.
Q. Why must ? Nothing was seen passing down the rod. How do you know ?
A. Well, perhaps it was in the rod; perhaps the rod heated from top to bottom.

Nothing passed down the rod—a rapid heating worked its way—to understand that is essential. There was indeed a shock or strain in the rod, the air, and the man, expressing itself as—

1. Electric-strain.
2. Light-strain.
3. Sound-strain.
4. Tissue-change.

Go into any library and count the number of books entitled " Electricity." It may be handy to speak of " electricity " as a " current " passing along a copper wire, thinking of the current as a ball running down a pipe. But it is a mistake to speak of anything which, so far as we know, does not exist. " Electricity " is an altered state of Matter—Matter in strain.

Touch the electric button, and on goes the electric light. Has anything run through the copper wire to the carbon filament of the globe ? We have no reason to think so. All we know—all we are at liberty to assume—is that the copper of the wire has changed, one end changing and then the wire changing right along to the carbon filament, thence back again to the other end. Take the following analogy : Magnify the changes, and let an engine strike a row of trucks ; the trucks then go jolting each other right along, till the last truck shoots off on its own. The copper wire can be thought of as altering along in similar fashion (fig. 241).

We may now sum up strain as follows :—

To project our individual sensations of heat-strain and electric-strain in the skin, light-strain in the eyes, and sound-strain in the ears ; to project these states of strain into which our tissues have

passed, and to worship them as external quantities of energy, external both to the Matter from which they proceed and to ourselves to whom they come, is not right. It is always the Matter itself—the tissue, the earth, the water, the air, or the æther—that strains, pulls or pushes, tugs or thrusts, and there is no strain apart from Matter. How, then, can we project the action of Matter into space apart from that Matter ?

It may be urged, if " heat," " light," " sound," and " electricity " do not exist, but merely a general strain in Matter, why do we not see sounds and hear lights. But the argument is not that all strains are exactly alike, which would be an absurdity in view of the specialisation of our eyes for light-strains and our ears for sound-strains.

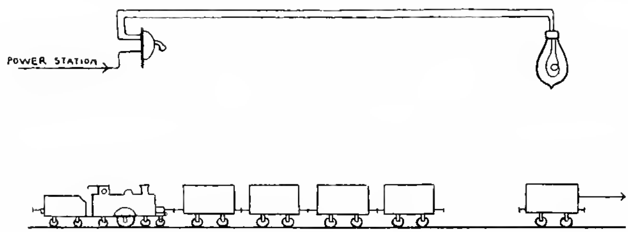


FIG. 241.—To illustrate nature of electric change in a wire.

The argument is that not one of these different strains possesses an independent existence external to and apart from Matter.

Which is right—the Cause-effect idea or the Action-strain-result idea ? We do not know. But we can easily see how the Cause-effect idea leads us to regard minerals, plants, animals, and man as passive, reflex, and mechanical things ; while the Action-strain-result view leads us to think of them as active.

For the Cause-effect idea allows only for a closed series of possibilities. Suppose all the movements of any piece of Matter, M, have been analysed and then summed up in the following series of terms, these representing the possible movements, forces, or energies of M :—

$$A + A_1 + A_2 + A_3 + A_4 \text{ etc.}$$

By the term passive is meant that all the energies of the Matter, M, can be exactly measured and then summed up as a finite sum. If this idea of the nature of M be correct, it cannot be said to possess any spontaneity or existence of its own. It is but a summation of

forces, which it can neither add to nor subtract from. We will regard the form of Matter, M, as composed of a finite number of " units," " quantities," " factors," " forces," or " energies," but as containing no force which is beyond complete analysis by the human mind. Everything moves, but motion is no proof of life.

By the term active, on the other hand, is meant that however far the Matter be analysed, there is always something left over still to be analysed. In other words, the series

$$A + A_1 + A_2 + A_3 + A_4 \text{ etc.}$$

is an inexhaustible series reaching to infinity.

In Passivity, the form of Matter, M, is the intermediary of certain forces. In Activity it is the transformer or modifier of certain forces, reducing or multiplying the theoretical effects of the action applied to it.

Or to consider the distinction in another light. Take a piece of Matter, M, and act upon it 100 times, keeping all the acting factors or causes, external and internal, as far as possible identical. Then apply external test, knowing every element in it too, and watch the result: the following distinction may then be drawn :—

Passive Change = An identical cause
leads to
A Constant Result.
Active Change = An identical cause
leads to
An Inconstant Result.

If the change of Matter be passive, we could say with Herbert Spencer in his *First Principles*, p. 194, " Let two equal bullets be projected with equal forces ; then in equal times, equal distances must be travelled by them."

But if the change be active, then we say, " Let two equal bullets be projected with equal forces ; then in equal times, unequal distances must be travelled by these."

Let us now decide which. In the first case, Matter is like a soldier obeying orders implicitly and without responsible criticism. In the second case, like Nelson at the battle of Copenhagen, it takes its orders in its own hands, changing them every time.

Obviously, these statements cannot both be correct. If one be

true, the other is false ; if one be false, the other is true. And this is a distinct help and advantage.

Someone may urge, What really does it matter what our mental attitude is so long as we get at the facts. What is the cash equivalent of a mental attitude ? This while apparently practical is the reverse, for it is superficial. A right attitude towards the changes occurring in Matter is not negligible, but of supreme importance if any results are to be achieved. Without a right attitude we might collect scientific details by the ton, and yet be not a whit better off ; for the details are then isolated corks upon an ocean—quite at sea. And not merely would the details be lost and vitiated if our attitude chanced to be wrong, but the ensuing dissociation of ideas would render it extremely difficult for any young man or woman, no matter his or her ability, to rise to that orderly and related view of modern knowledge without which his work will lose, at least some of its value. They would lose time. They would wander aimless in the dark tangle and shadow of the trees, and die there without ever a glimpse of the sun beating on the leaves above them. If the harm were only that a few additional details were not discovered, it would be little odds. But the trouble is that society does not advance beyond the bounds of its knowledge ; it is difficult for social and political heart and hand to outstrip the head of a nation, for it acts only on what it thinks. It is ever the helm of the State, in the sense that it can direct social enthusiasm verily on to the rocks. Strange as it may seem to a man immersed in business—and at first sight it *is* strange—it is quite possible for an apparently theoretical idea to hold up and indefinitely to retard the social progress of a community, to hold back, for instance, the housing conditions of a whole land.

Far away in the heart of the Rockies, 5000 feet and more above the level of the ocean, the curve of the Canadian Pacific Railway attains its summit. The spot is called " The Great Divide."

Shall we turn East or West ?

NINTH STEP.

TO THE LAW OF ACTIVITY.

Sequence of Reasoning.

What is strain ?

Measurements by Alfred Russel Wallace on the American rice-bird and marsh-blackbird.

Does the strain of inbreeding lead to divergence from type ?
Is change active or passive ?
The advantages of using bones for the test.
The measurer.
The difference-figure, $\frac{\text{Range}}{\text{Mean}}$.
Inadequacy of the difference-figure, $\frac{\text{Range}}{\text{Mean}}$.
Acceptance of the " Standard Deviation " method

$$=\frac{\text{sum of squared differences from mean}}{\text{number of units}}$$

and the difference-figure based on it,

$$\text{D.F.}=\frac{\text{Standard Deviation}}{\text{Mean}}\times 100.$$

Preliminary test on 400 kneecaps.
The thigh bone of man and its peculiarity.
First test, on the thigh bone.
Second test, by independent measurer, on the thigh bone.
Countering of some objections.
A tissue in strain responds to *opposite* sides of a mean.
The law of the Activity of Matter.

We have just stepped to the firm footing of a strain within Matter. So far the climb has been easy, as over the lower and shouldering slopes. But now we come to a sheer ascent.

Has the average man or woman the slightest interest or desire to follow a pursuit of knowledge for its own sake ? Perhaps not, and yet perhaps ; for just as there are men and women who will venture the Highlands or the Alps out of a youthful delight in Nature, so there are those who look to the end and realise that a seedling

may grow into an oak, a babe into a man, and that in time both oak and man are useful.

So, starting from the clue, or thing, or idea, or springboard, or basis—or whatever word we like—of a strain or inner tension of tissue, let us attempt to reason out the nature of the changes we see all around us. Can it be seen, and heard, and felt ? Can it be produced by way of experiment ? Is it invisible, but real ? Or is it utterly beyond our common understanding ? Such are some questions to be answered.

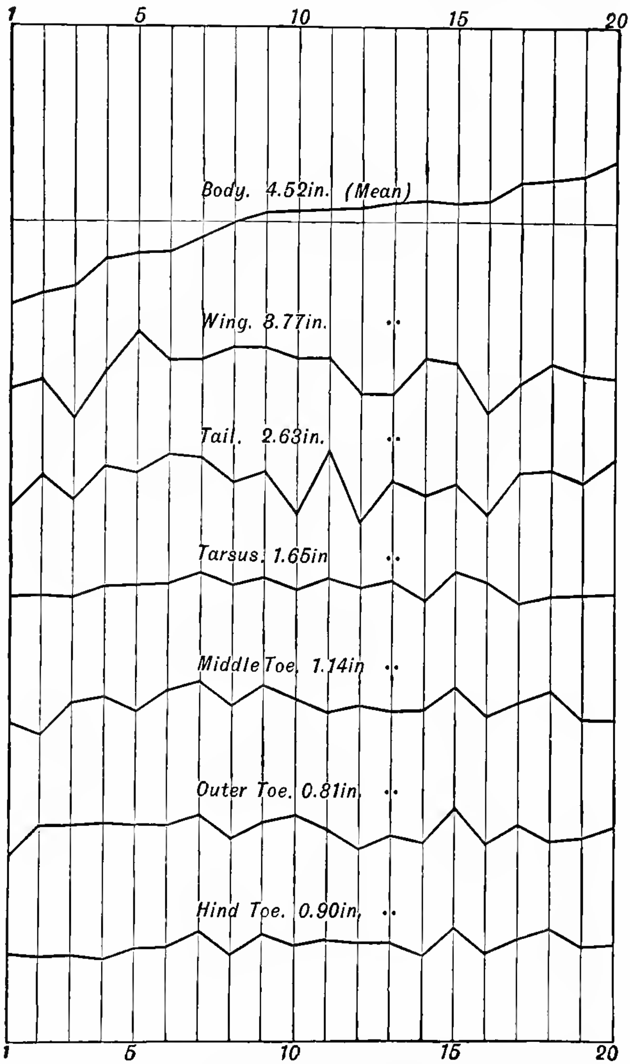
Let us go to others for help. Let us go to the leading authorities on plant and animal life. Now, in reading Mr Wallace's famous book *Darwinism* we come to his pictures of the different measurements in birds. Two of his figures are reproduced here : the first showing the measurements of twenty males of the rice-bird or bobolink, the American songster ; the second showing the measurements of forty males of the American marsh-blackbird.

Mr Wallace explains the construction of the first diagram as follows :—

> " The twenty specimens are first arranged in a series according to the body-lengths (which may be considered to give the size of the bird), from the shortest to the longest, and the same number of theoretical lines are drawn, numbered from one to twenty. In this case (and wherever practicable) the body-length is measured from the lower line of the diagram, so that the actual length of the bird is exhibited as well as the actual variations of length. This can be well estimated by means of the horizontal line drawn at the mean between the two extremes, and it will be seen that one-fifth of the total number of specimens taken on either side exhibits a very large amount of variation, which would of course be very much greater if one hundred or more specimens were compared. The lengths of the wing, tail, and other parts are then laid down, and the diagram thus exhibits at a glance the comparative variation of these parts in any specimen as well as the actual amount of variation in the twenty specimens."

We notice first in these pictures that the length of the parts do not always agree with that of the body, but are often in an opposite direction : the chart for wing and tail often strikes away from that given for the body as a whole. We notice next the average or mean point for each part of the body in fig. 243,

and we can take a pencil and draw through each average a horizontal line parallel to the line of the body-length. We thus

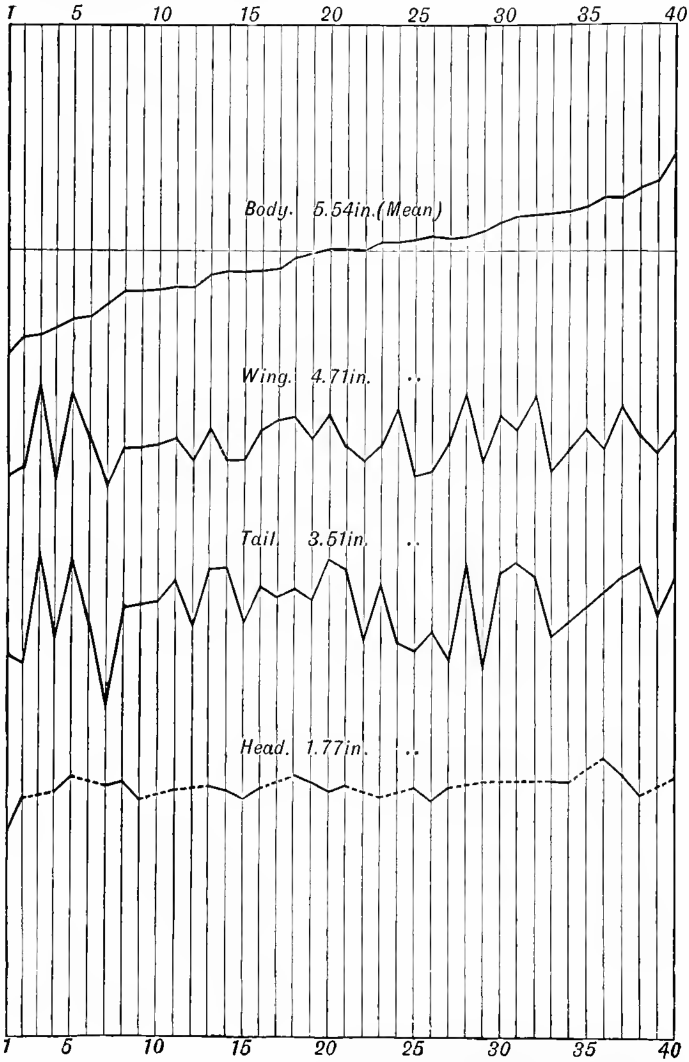


(*After Alfred Russel Wallace* (*Messrs Macmillan*).)

FIG. 242.—Variations in twenty specimens of the rice-bird.

secure the average line for each part. We now notice that the differences of the various parts, wing, tail, and so on, occur to

opposite sides of an average, sometimes above the lines we have drawn, sometimes below them.



(*After Alfred Russel Wallace (Messrs Macmillan).*)

Fig. 243.—Variations in forty specimens of the marsh-blackbird.

So far we have been considering a series of units. But a possible clue here presents itself, Does there exist not merely in this way

a number of differences over a series of tissue-units, but a power in *each individual unit* of tissue to change in similar fashion either to one or to the other side of the average ? Supposing we take all the differences of our line or series of units and crush them together as one presses a concertina, does this crushed picture represent the internal state of one unit ? An idea !

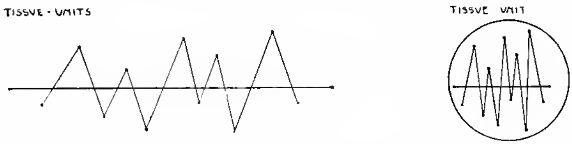


FIG. 244.—A series of units differing away from an average-value pictured as coalescing into a single unit hovering to opposite sides of an average-value.

Steady now ! To argue from a series of units to the single unit of units to the single unit of that series—that is, from the general to the particular—is a process open to grave objection. But still, it is possible. It is just possible to regard each form of tissue as delicately poised about an average, and changing to one or other side of it.

And still further, if you take 100 units of any tissue (A), say 100 rats, and another 100 units of another tissue (B), say another 100 rats, and find these nearly identical in extent of difference

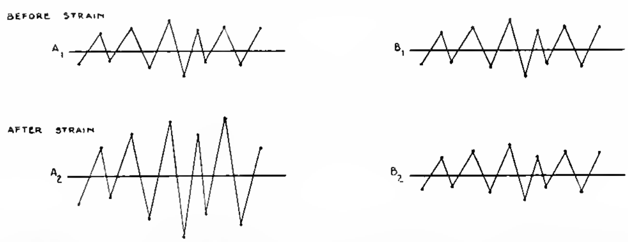


FIG. 245.—Question : Do a series of units, A, diverge to opposite sides of an average-value upon strain, as compared with a second group, B, kept in uniform conditions ?

from the average-line, either above it or below. Then if you excite the group A with some unusual action, say by the passage of an electric action through them, will the largest units of the group A begin to change away still further from the average and become larger than the largest of B, and the shortest of B, as in fig. 245.

Let us assume this as a working clue, just as Sherlock Holmes might make use of a clue in tracking down some mystery. But, then, what is the excitement we can use ? It is not easy in practice to keep 100 rats dancing round in an electric current to contrast them with the first 100 living in normal conditions. Such an experiment would occupy months and years, and we want to reason the matter out on the spot. Is there no short-cut test by which we can determine whether a tissue can be excited to differ from the average or not ?

Is not Inbreeding such a test ? It certainly appears to be a strain to the tissue, for it is known that inbreeding of animals may lead to the death of the race. Let us therefore take Inbreeding as a possible test of internal change of tissue ; or to put the point pictorially, to see whether inbreeding excites a tissue from A, of fig. 245, to A_2, from the normal away from the average of the series, the test to be as follows :—

(1) If close inbreeding leads to no increase in the range of tissue-differences, then strain does not lead to change.
(2) If close inbreeding leads to an increase in the range of tissue-differences, then strain does lead to change.

Reference to the literature discloses that the three leading authorities upon evolution in Europe suggest inbreeding to lead to change :—

Darwin, in " The Origin of Species " :—

" It is an old and almost universal belief founded on a considerable body of evidence, which I have elsewhere given, that slight changes in the condition of life are beneficial to all living things. We see this acted on by farmers and gardeners in their frequent exchanges of seed, tubers, etc., from one soil or climate to another and back again. During the convalescence of the animals, great benefit is derived from almost any change in their habits of life. Again, both with plants and animals there is the clearest evidence that a cross between individuals of the same species, which suffer to a certain extent, gives vigour and fertility to the offspring ; and that close interbreeding continued during several generations between the nearest relations, if these be kept under the same conditions of life, almost always lead to decreased size, weakness, or sterility."

Darwin, in "The Origin of Species":—

"The offspring from the first cross between two pure breeds is tolerably and sometimes (as I have found with pigeons) quite uniform in character, and everything seems simple enough; but when these mongrels are crossed one with another for several generations, hardly two of them are alike."

Darwin, in "Animals and Plants":—

"Instances of inbred animals being liable to malformation have been recorded in the case of pigs, bloodhounds, and some other animals."

Wallace, in "Darwinism":—

Of experiments upon hogs he narrates: "After a few generations the victims manifest the change induced in the system. They become of diminished size; the bristles are changed into hairs; the limbs become feeble and short; the litter diminish in frequency and in the number of the young produced; the mother becomes unable to nourish them; and if the experiment be carried as far as the case will allow, the feeble and frequently monstrous offspring will be incapable of being reared up, and the miserable race will utterly perish."

Weismann, in "The Evolution Theory":—

"Continued inbreeding leads in many cases to the degeneration of the descendants, and particularly to lessened fertility and even to complete sterility. Thus in my prolonged breeding experiments with white mice, which were carried out by G. von Guaita, strict inbreeding effected throughout twenty-nine generations resulted in a gradually diminishing fertility, and similar observations have been made by Ritzema Bos and others."

Ritzema Bos's experiment made on rats extended to seven years, and must have been done with some care, for out of thousands of rats he had only twelve deaths from paralysis, which in these animals is a not uncommon disorder. He did not observe many abnormalities among his inbred animals, but rather a gradual sterility associated with a loss in body-weight. His figures for (A) the average number

of young per litter, (B) the number of sterile pairings, in percentages, (C) the percentage death-rate of young, are these :—

	1887.	1888.	1889.	1890.	1891.	1892.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
A	7·5	7·1	7·7	6·6	4·6	3·2
B	. .	2·6	5·6	17·4	50·0	41·2
C	3·9	4·4	5·0	8·7	36·4	45·5

The number per litter decreased, there were more sterile marriages, and a rising death-rate in the inbred young.

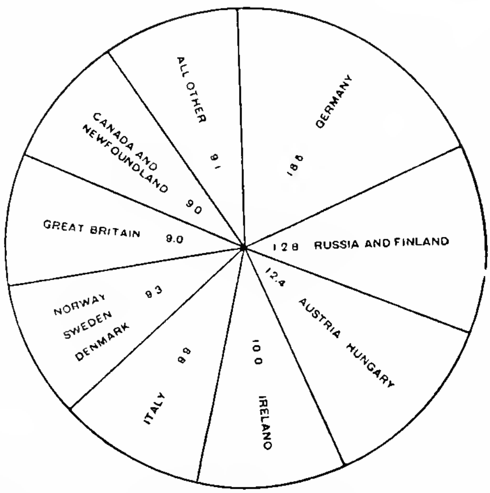


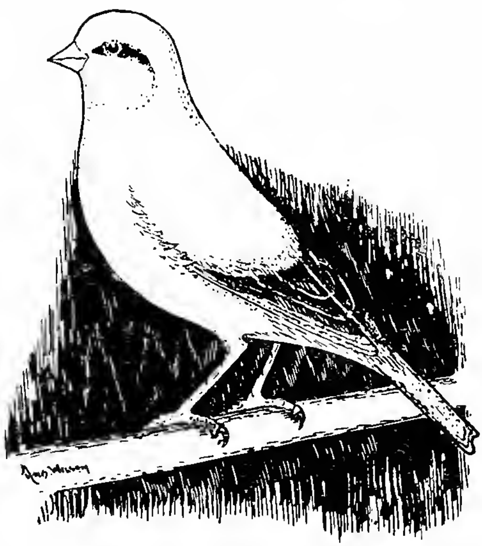
FIG. 246.—Race admixture in the U.S.A. : from Census Report of 1910. Foreign-born population by principal countries of birth, numbering 13,575,886.

The rabbits in the small Copeland Islands, near Donaghadee, in the north of Ireland, are repeatedly swept by epidemics of disease. Even in the vegetable kingdom, though virgin-birth is common, many different forms of flowers in plants of the same species are self-impotent or specially adapted to be fertilised by the pollen of another form ; this is possibly to avoid the strain of inbreeding, for in some orchids self-pollenisation not merely diminishes the fertility, but appears to act in a directly poisonous manner, the self-pollenised flowers falling dead in a few days.

The results of inbreeding are seen sometimes even when a single character is taken. Charles Darwin quotes a successful breeder of laced Sebright bantams :—

> " I am confident that the two that are best laced frequently produce offspring very far from perfect in their markings, whilst those exhibited by myself which have so often proved successful were bred from the unison of heavily laced birds with those that were scarcely sufficiently laced " (*Animals and Plants*).

In canary-breeding, if the aim is to produce an " even-marked " canary, a bird, that is, with pronounced markings on the wings



(*By Andrew Wilson.*)

FIG. 247.—Even-marked canary.

and a pear mark behind each eye, breeders (who are men interested) do not put an even-marked to an even-marked bird. As Darwin remarks, " If two crested canaries are paired, the young birds rarely inherit this character."

Thus the inbreeding even of selected characters appears to lead to change from type.

Accordingly, from all these evidences one is led to think the strain

of inbreeding does indeed bring about a rise in the divergent tendency of tissue.

Yet all this is not conclusive. The evidence is a trifle to the vague side. It is difficult in practice to secure an absolutely true inbreeding; for the race may either die off before any tangible result is attained, or fresh blood comes in by accident and spoils your experiment. Then there is the difficulty of close confinement: cooping up benefits no animal, not even hens; and there were years of close quarters in Ritzema Bos's experiment. Then there is the factor of selection—natural, sexual, or artificial—to reckon with. The Porto Santo rabbits have lived successfully on a small island for hundreds of years, though they originated from a single litter; but there, no doubt, the weakest specimens were eliminated in every generation, leaving only the sturdiest forms to mate; and if the weakest are to be killed off by natural selection, then your experiment vanishes. On the other hand, when you interbreed in confinement, do you not artificially preserve inferior types which natural selection would tend to destroy?

Then again in man; while there is a prejudice against cousin marriages, indeed because of that very prejudice, any bodily defects will more readily attract attention and be rated of a higher importance than they deserve.

Finally, breeders themselves are quite at variance on the matter. Mr Cross, manager of the Liverpool Menagerie, writes:—

> "It is my emphatic opinion that inbreeding leads to anatomical alterations, most marked defects on the brain, and in the majority of instances causes what we would term monstrosities."

Whereas Mr D. M'Dougall of Ardtalnaig, Loch Tay, writes:—

> "In my opinion, inbreeding does not lead to alteration from type in animals. It is practised by breeders of stock to enable them to produce what is considered to be the typical or perfect specimen."

One breeder of highly-bred ponies went as far as to boast that he had a filly so prepotent through inbreeding that, though she were sent to the best Clydesdale stallion in Scotland, she would throw a colt showing no cart-horse blood, provided always the Clydesdale was not also the product of inbreeding. And the Jews are said,

through their national inbreeding, to be prepotent over Catholics and Protestants—the possible beginnings of a sterility barrier, a self-isolation of a race.

The inbreeding problem is still more complicated by the possibility that inbreeding may bring to pass not a decrease but an increase of fertility.

So now in fact, instead of our question of Inbreeding helping us to an acuter comprehension of Strain, it seems to be a will-o'-the-wisp, landing us into a morass of conflicting details and defiant convictions. And even admitting the strain of inbreeding has led to an increased change in the animals exposed to the test, this change is open to two possible explanations :—

(1) The change is a real divergence of the tissues from one state to another.
(2) The change is false ; for just as we loosen a number of faggots by cutting the binding cord, so the increased change may be not a new thing at all, but only a passive unfolding, a loosening, a falling out, an unmarking of hereditary tendencies already present.

Change, in short, may be either active or passive.
Strain may be either active or passive.
Which is it ?

From the Contrast between Passive Change and Active Change.

A decision between these two opposing views is very desirable. How can we win it ? By arguments of a general nature ? No ! By accurate measurements ? Possibly ! So let us measure.

But whereon shall we measure man with accuracy ? Upon the bones. For upon them are photographed and registered the lives of the past, from generation to generation. Because :—

(1) They are plastic,
(2) They are hard and easily to be handled, and
(3) They are available in large numbers.

For in the charge of the University of Cambridge, in the new museums of that city, there lies a collection of many thousands of

ancient human bones, brought thither from Egypt, some of them over 6000 years old. "Can these bones live?"

How shall we measure these bones? Why! by means of a two-bladed metal calliper, read off in centimetres.

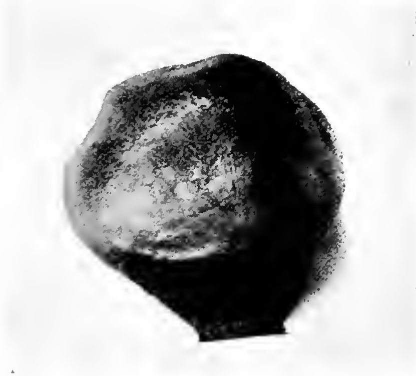
Which bone shall we measure first? Well, there are hundreds

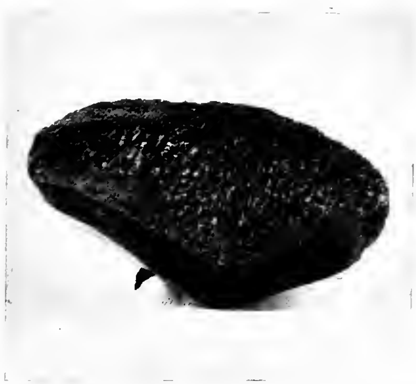
Fig. 248.—Measurement: callipers grasping neck of thigh bone.

of bones, and we may as well take one at random, say a kneecap. Pick one up and feel it. It has three dimensions :—

L. The longest measurement from above down.
B. The broadest measurement from side to side.
D. The deepest measurement from before backwards.

Measure these three dimensions by means of the metal calliper. Good! Let us do the same to 399 others, making 400 kneecaps in all.





Figs. 249, 250, and 251.—Three kneecaps.

(1) Large, (2) small, (3) cut to show bony comb.

KNEECAPS.

L.	B.	D.
3·2 (2)	3·0 (1)	1·4 (2)
3·3 (1)	3·1 (1)	1·5 (3)
3·4 (16)	3·3 (1)	1·6 (11)
3·5 (25)	3·4 (4)	1·7 (32)
3·6 (30)	3·5 (4)	1·8 (64)
3·7 (36)	3·6 (16)	1·9 (71)
3·8 (35)	3·7 (28)	2·0 (75)
3·9 (38)	3·8 (31)	2·1 (72)
4·0 (37)	3·9 (29)	2·2 (40)
4·1 (45)	4·0 (32)	2·3 (16)
4·2 (35)	4·1 (56)	2·4 (11)
4·3 (30)	4·2 (33)	2·5 (3)
4·4 (28)	4·3 (38)	400
4·5 (16)	4·4 (28)	
4·6 (6)	4·5 (26)	
4·7 (10)	4·6 (19)	
4·8 (3)	4·7 (15)	
4·9 (3)	4·8 (14)	
5·0 (1)	4·9 (13)	
5·1 (1)	5·0 (5)	
5·2 (1)	5·1 (4)	
5·4 (1)	5·2 (1)	
400	5·3 (1)	
	400	

Having these measurements, are we any wiser ? We have next to calculate these figures for each dimension into such a single figure as will enable us to compare the figures of one dimension, say the series for length, with the figure of another dimension, say the series of breadth.

Now on reference back to Mr Wallace's diagrams of different measurements in birds one observes a line representing the average-value, and a series of points to either side of that line ; further, there is one point highest above the average line (the maximum), and another point lowest below the average line (the minimum). Suppose, then, one were to take the maximum measurement of any series of units and the minimum measurement, subtract the one from the other, and then divide this figure of range by the average-value (represented in Mr Wallace's diagrams by the line), does not this give a fair measure or figure of difference

for that series, a measure of the spread of the series away from the average or mean :—

1. The Range, or maximum less minimum,
2. The arithmetic average or mean,
3. Difference-figure $= \dfrac{\text{Range of Units}}{\text{Mean of Units}}$,

provided of course the maximum or minimum were not extreme figures, but formed part of a gradual series, and each series con-

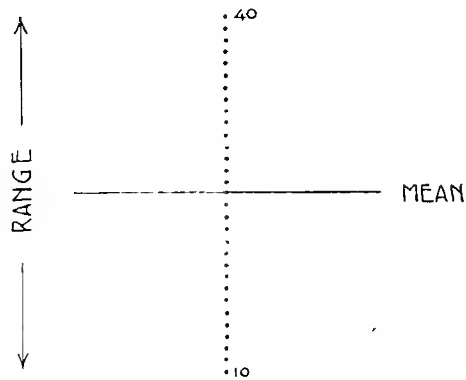


FIG. 252.—Range upon mean.

taining an equal number of units. This would work out in the first kneecap series—

$$\frac{5 \cdot 4 - 3 \cdot 2}{4 \cdot 2} = \frac{22}{42} = \cdot 55\,;$$

in the second kneecap series—

$$\frac{5 \cdot 3 - 3 \cdot 0}{4 \cdot 2} = \frac{23}{42} = \cdot 55\,;$$

in the third kneecap series—

$$\frac{2 \cdot 5 - 1 \cdot 4}{1 \cdot 95} = \frac{110}{195} = \cdot 57$$

Reference was now made to Mr G. Udny Yule's *Introduction to the Theory of Statistics*, and it was found that the experts do not object to the use of the arithmetic average or mean in carrying out calculations—indeed the very reverse :—

> "The arithmetic mean should invariably be employed unless there is some very definite reason for the choice of another form of average."

But the same cannot be said of the Range or maximum less minimum part of the Difference-figure; which is open to the following trenchant criticism of Udny Yule:—

> "The simplest possible measure of the dispersion of a series of values of a variable is the actual range, *i.e.* the difference between the greatest and least values observed. While this is frequently quoted, it is, as a rule, the worst of all possible measures for any serious purpose. There are seldom real upper and lower limits to the possible values of the variable, very large or very small values being only more or less infrequent; the range is, therefore, subject to meaningless fluctuations of considerable magnitude according as values of greater or less infrequency happen to have been actually observed. Note, for instance, the figure showing the frequency distribution of weights of adult males in the several parts of the United Kingdom. In Wales one individual was observed with a weight of over 280 lbs., the next heaviest being under 260 lbs. The addition of the one very exceptional individual has increased the range some 30 lbs., or about one-fifth. A measure subject to erratic alterations by casual influences in this way is clearly not of much use for comparative purposes. Moreover, the measure takes no account of the form of the distribution within the limits of the range; it might well happen that, of two distributions covering precisely the same range of variation, the one showed the alterations for the most part closely clustered round the average, while the other exhibited an almost even distribution of frequency over the whole range. Clearly, we should not regard two such distributions as exhibiting the same dispersion, though they exhibit the same range" (p. 133).

Thus in the fig. 253, the total range (maximum–minimum) of the A 12 units is the same as that of the B 12 units, but the distribution in A clusters more closely round the mean. Or the distribution may be different, not clustering towards the mean, but towards an extreme—as in the distribution of wealth in Britain to five out of the forty-five millions of the population.

This criticism does not quite knock out the simple Difference-figure

$$\frac{\text{Range of Units}}{\text{Mean of Units}},$$

but it urges us to look for one more exact. Surely some measure of dispersion is attainable, based on all the observations made, so that no single observation can exercise an unduly preponderant influence on the result.

According to Udny Yule—and he seems to know his subject—this aim is fulfilled by the " Standard Deviation " method of estimating the dispersion or spread of a series of units.

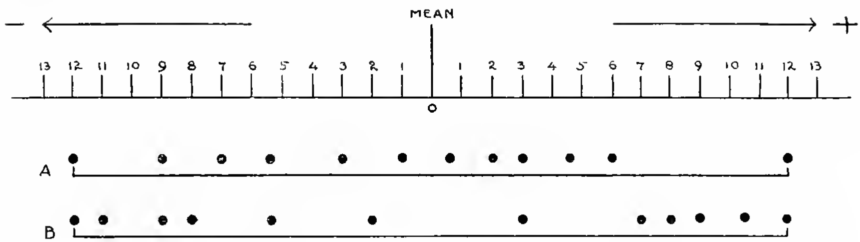


Fig. 253.—Different distribution of two series of units.
A. About the mean. B. Towards the extremes.

The Standard Deviation Method.

" The standard deviation possesses the majority at least of the properties which are desirable in a measure of dispersion. It is rigidly defined ; it is based on all the observations made ; it is calculated with reasonable ease ; it lends itself readily to algebraical treatment ; and it is the measure least affected by fluctuations of sampling " (p. 143).

That being so, let us see what this " Standard Deviation " method is :—

> " The standard deviation is the square root of the arithmetic mean of the squares of all deviations, deviations being measured from the arithmetic mean of the observations. If the standard deviation be noted by S.D., and a deviation from the arithmetic mean by x, then the standard deviation is given by the equation
>
> $$\text{S.D.}^2 = \frac{1}{\text{N}} \text{S}(x^2).$$

"To square all the deviations may seem at first sight an artificial procedure, but it must be remembered that it would be useless to take the mere sum of the deviation in order to obtain a measure of dispersion, since this sum is necessarily zero if deviations be taken from the mean. In order to obtain some quantity that shall vary with the dispersion it is necessary to average the deviations by a process that treats them as if they were all of the same sign, and squaring is the simplest process for eliminating signs which leads to results of algebraical convenience" (p. 134).

In other words, if one were to take merely the deviations from the mean-value, the plus figures to the one side would neutralise the minus figures on the other side; 2 would neutralise -2; so we

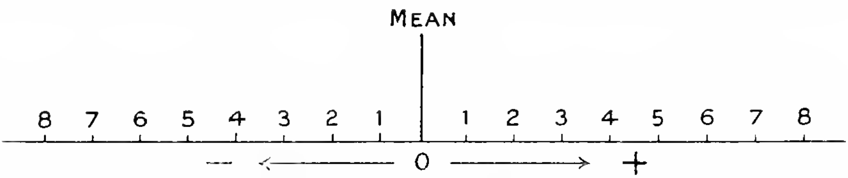


FIG. 254.—To opposite sides of mean.

square $(2)^2$ and $(-2)^2$, add them together, do the calculation, and then finally extract the square root at the end of the calculation.

What the method comes to is this. First find out the average value of your series, then find the amount of difference of each unit of the series, and add up all the differences in number, after taking care to bring them all to the same sign by squaring them; this gives the sum of the differences squared; then divide this total sum of differences by the number of units in the series; and seeing this calculated figure has been reached through squaring, it has now to be reduced by extracting the square root. The method may be stated in the following four stages:—

1. Determine the mean-figure of the series.
2. Determine the difference from the mean in both (plus and minus) directions for every individual unit on the series.
3. Square the figures of all the differences, multiply each of these figures by the frequency of the corresponding unit, sum all up the quotients, and divide by the total number of units.

4. Take the square root of the resulting figure.

Where d = the difference of each unit from the mean,
S = summation,
N = the number of units in the series,
and S.D. = the standard deviation,
then $Sd = \frac{S(d)^2}{N}$.

This Standard Deviation method looks dreadfully difficult on paper, but it is really not so bad.

But suppose we manage in this way to calculate out the degree of dispersion and spread of 100 or 400 bones to the two sides of the average or mean, how are we to compare the spread of this series from the mean with the distribution of another from *its* mean? How can we compare a series of, say, our 400 kneecaps, some 4 centimetres long, with that of thigh bones some 40 centimetres long, or with the length of leaves, or with the stature of living men and women?

This is easily managed by expressing the standard-deviation figure in terms of the average-value of each series of measurements, and then, in order to present the result in a clear way, to express the result in percentage terms. Thus:

$$\text{The difference-figure} = \frac{\text{The standard deviation}}{\text{The mean figure}} \times 100,$$

or

$$D-F = \frac{S-D}{M} \times 100,$$

and this D—F based on the standard-deviation method is the one generally used for accurate work; it is usually written not D.F. but, for short, v.

Having now obtained the first bit of kit, a reliable method of comparing and contrasting the differences of tissues, let us proceed to test the theory of strain, to ascertain whether it is in real accord with fact. The tests of every theory are:—

1. Its power to explain all known facts and to meet all objections.
2. Its applicability as an instrument of research.
3. The power of prediction.

The last of these is by far the most searching.

The theory is that strain in tissue stimulates an increased divergence from the mean-value of that tissue. The test is the production that the difference-figures of the human body would be highest at the points of especial strain.

And first test the theory from the negative standpoint. The kneecap is a bone in which the strains are fairly evenly spread, and if this is so, the difference-figures for length, breadth, and thickness should all work out pretty equal. So the measurements for the kneecap, as already stated, were calculated.

All the calculations were carried out by Mr John Dougall, mathematician, of Glasgow. The calculations of the mean-figures and difference-figures in the 400 kneecaps were these :—

	M.	D–F.
L . . .	4·01	9·2
B . . .	4·18	9·3
D . . .	1·97	9·9

Though the mean-figures are different, the difference-figures work out almost to an identical figure. This makes us think that the difference-figure is reliable, being independent of the mean-figure.

In this case the strain is fairly similar, and we get similar difference-figures ; so if in another case the strain is different, there ought to be revealed a dissimilarity in the difference-figures.

The Thigh Bone.—But next, were there any points in any of the bones where especial strain occurs ? Nature always tends to equalise strain and distribute it from one part of the body to another, and from one part of a bone to another part, and, after distribution has been going on for thousands of years, it is doubtful whether any differences will be disclosed, even at specially strained points. Yet there was one point where possibly Mother Nature would give herself away, so to speak—namely, at the neck of the thigh bone, for there is an excessive strain at that point.

The shape of this bone is shown in fig. 255. It is one of the long bones ; its rounded head rests in the hip joint. It will be observed that it is bent near the head ; this upper bent portion is called the neck. The reason the bone is bent is to allow of swinging-round

movements at the hip, as, for instance, in the professional footballer. Obviously, if there were merely a round head on a straight shaft the whole limb would go swinging round like a flail, just like the ball-

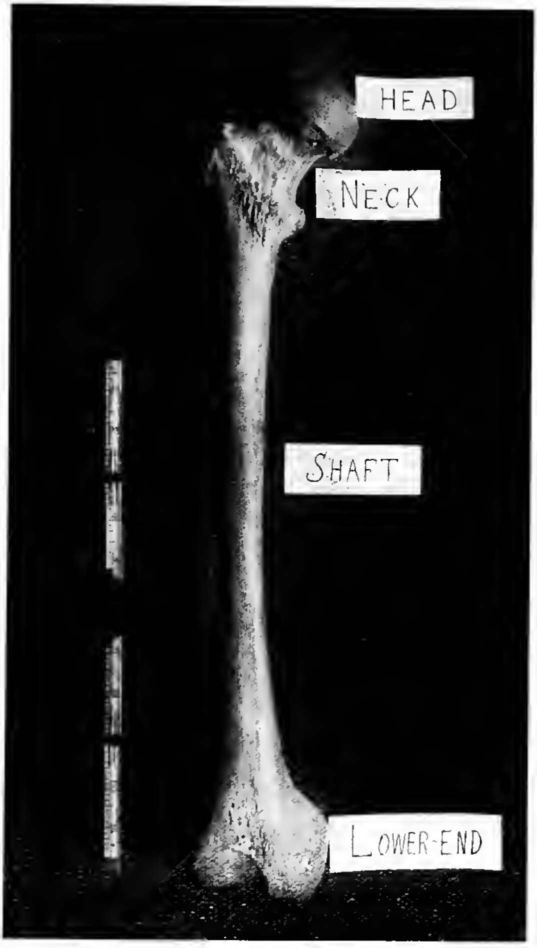


FIG. 255.—The human thigh bone and a foot-rule.

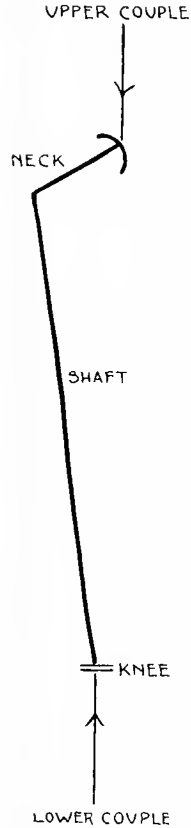


FIG. 256.—Showing how the thigh bone is compressed between the weight of the body from above and the earth from below.

and-socket movements of the arm at the shoulder joint ; on the other hand, if swinging movements were rigidly prevented by the formation of a hinge joint like the elbow, the leg would always move straight backwards and forwards, and the turning movements, as of the foot-

baller, would be quite impossible. So to secure (1) rigidity, and (2) turning and swinging-round movements, Nature has resorted to the dodge of providing the thigh bone with a distinct neck. This neck enables man to swing his legs in a wide circle away from his body without falling; it secures him both stability and variety of movement.

But these advantages are bought at a price. A reference to fig. 256 will illustrate. The weight of the body is resting on the head (H); the counter-resistance from the ground upwards is transmitted up the shaft (S); the neck therefore forms an oblique arm between a couple (1) acting from above and a couple (2) thrusting from below. A glance at the diagram is enough to reveal to us that the neck of the thigh bone is subject to an excess degree of strain. One does not need to be read in the principles of mechanical engineering to appreciate the point. To put the matter in simple terms, the neck is forced to bear not merely the direct vertical weight of the body, but is subject to an additional transverse strain as well. Nature, as will be indicated below, has tried to arrange to meet this excess of strain. But nevertheless, as the neck is shorter than the shaft and forms a more transverse bend of the bone than does the shaft, it should follow that the strain per cubic content at the neck is greater than the strain per cubic content at any other part of the bone.

Now it is usual in mechanics and engineering to describe strain under various headings—tension, compression, and so on. If we take a beam and load it with a weight, we may set up such a reaction as in fig. 257.

This reaction is termed a bending moment. But if the reaction be of the sliding kind, as in fig. 256, or as when we set our hand upon a packet of cards and slide the top upon the bottom half, this reaction is called the "shearing" moment. The bending reaction may be further resolved into (1) force of tension, (2) force of compression; this may be illustrated by taking a green bough and bending it over one's knee; the skin on the one side becomes stretched, on the other it becomes compressed into wrinkles. A peculiar combination of tension, compression, and shearing is torsion, as when one takes the bough of a sapling and twists it round and round.

Now, all three of these reactions occur at the neck of the thigh bone; thus, a *bending* process is seen when in certain exceptionally

plastic and soft bones the neck is pushed by the weight of the body from the oblique to a transverse position ; a *shearing* process can be illustrated when, as not infrequently in old age, the neck fractures ; a *torsion* process is evidenced by the lines of twist in the necks of many thigh bones. But not one of these reactions can be in practice isolated and considered separately from the others, and for a simple reason, namely, the effects of the weight of the body upon the neck are not limited to the neck but are transmitted also down the shaft, thus rendering precise estimation of the mechanical strain to any one point quite impossible. Bending, shearing, and torsion are but three of the terms used in labelling the response of engineering material to mechanical strain : if one refers to the engineering books, numerous

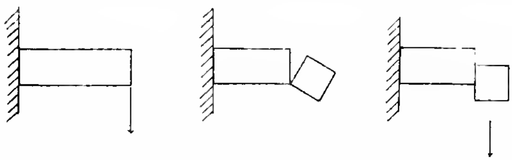


Fig. 257.—To illustrate the difference between bending and shearing.

other points will appear. These minute considerations, however, are of no use in the case of a bone. For over the thousands of years of evolution the bones have compensated for strain, and distributed it from one point to another of from one age of life to another in so many ways as completely to baffle precise estimation. Nature abhors a perpetual excess ; and Nature dealt with the excess of strain set up in the neck of the thigh bone in such obvious ways as :—

(1) The shaft of the thigh bone of man does not run straight up and down, but is directed inwards as well as downwards, as can be seen by watching any woman walking in the street. A moment's consideration of fig. 255 indicates that this inward tilting will relieve the neck of the femur of some of its excess strain and distribute it to the shaft.

(2) The before-backwards flattening seen in the neck of the thigh bone is not confined to the neck, but extends down the shaft. Indeed, in a few bones this flattening of the shaft in continuity with that of the neck is so marked as to give the whole bone not only at the neck but also right

down the shaft a flattened, scimitar-like form. These cases indicate that the strains of bending, shearing, and torsion are not confined to the neck, but extend also to the shaft as well.

And we must not think that this distribution of strain from place to place is limited to the thigh bone either; it probably affects also the lower leg right to the foot and above, the hip cavity, the hip bones, and even the spine and head itself. We cannot think of the thigh bone as an independent entity isolated from the neighbouring structures.

FIG. 258.—A normal thigh bone (left). A sideways flattened thigh bone (right).

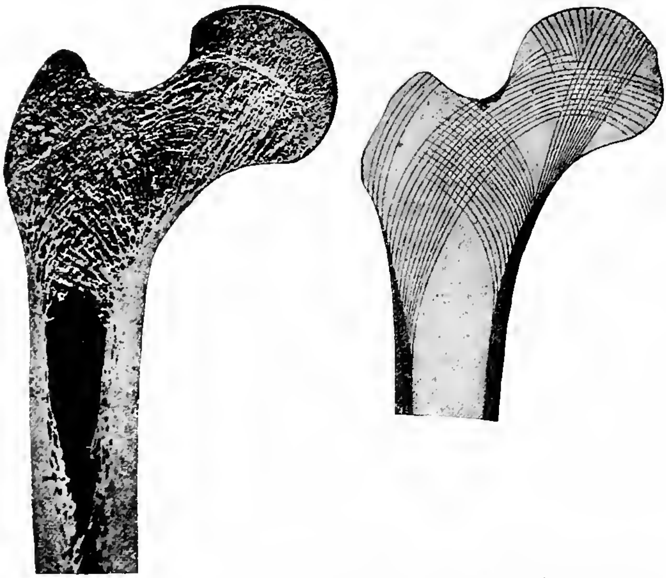
The question at once arises, Has Nature succeeded in effecting *complete* compensation; has Nature managed so to distribute strain as to prevent an excess of strain occurring in any one point, *e.g.* the neck? Obviously, if the distribution of strain has been successful, the difference-figures for the various parts of the thigh bone will be practically the same, just as in the case of the kneecaps; whereas if Nature had just failed to effect complete redistribution of strain, then the difference-figure for the neck will *not* be the same as for other parts of the thigh bone, but will be different.

Excess of Strain at Neck of Bone.—Now, though Nature has had such a long time to effect compensation of strain between neck and shaft, the following considerations indicate that complete compensation is unlikely, and that an excess of strain is indeed set up in the neck of the bone :—

(1) The mechanical difficulty (already noted) that the neck of the bone constitutes the crank or arm between the weight of the body from above and the answering upward thrust from the ground and foot.

(2) The interior of the neck is provided with a specially strong series of bony girders to bear the strain. If a thigh bone

be sectioned, the shaft is seen to be a hollow cylinder, but as one traces it upwards into the neck one sees a mass of interlacing bony girders honeycombing the interior of the neck in all directions. It can even be seen that these bony girders or struts are arranged in the form of definite arches calculated to meet the especial strain. These arches are "sound" from a mathematical point



(*After Wolff, von Meyer, and Oscar Hertwig.*)

Fig. 259.—Section of upper end of thigh bone, showing the thin strengthening bony girders.

of view, and being wafer-like in their thinness, effect their purpose of strengthening with a minimum of material. Some of these bony arches are so important as to receive special names. The bony arches in the interior of the bone are represented in fig. 259.

(3) The neck of the bone often fractures in old age. Thus an elderly lady may be walking downstairs, feel herself suddenly stumble, and then fall. The neck of the bone should always be looked to in these cases: it is often found to have broken. It is probable that in many such instances it is not the stumble that breaks the bone, but the break

> that occasions the stumble. But whatever the explanation, the fact is known even to a first-year medical student that the thigh bone of the aged is exceedingly prone to give way upon slight violence at the neck rather than at other parts.

Therefore, whether we consider the external contour, the internal structure, or the yielding of the neck in old age, we are impelled to believe that strain falls specially heavy at the neck of the thigh bone.

And as the strain would thus appear to be greater at the neck of the thigh bone than in the rest of the bone, we would expect to find the difference-figures of a series of neck measurements to be higher than a series of measurements made at any other part of the bone. That is a prediction made on the theory that there exists a relation between the degree of strain in a tissue and the changes that tissue displays.

If, on the other hand, the facts are found not to corroborate the prediction or to contradict it, we are bound either to declare the prediction unproven or to declare it false.

Let us put it to the test. Let us measure a series of thigh bones at the narrowest points, (1) of the neck, (2) of the shaft in its middle third. And let us do this in 500 specimens, which is a good round figure. And let us calculate out the results, not for the whole 500, but *for each hundred separately*; for this will surely test our prediction to the uttermost.

The difference-figures for the narrowest neck measurement and narrowest mid-shaft measurement were as follows :—

	Neck.	Shaft.
1st 100	10·1	7·7
2nd 100	9·9	9·1
3rd 100	10·5	8·7
4th 100	12·8	10·7
5th 100	10·3	8·7

The figure for the neck hundreds is higher than the figure for the shaft hundreds in every case. And the prediction is supported.

It is well to note, also, that this difference of the necks from the

shafts is quite independent of the average-figures, which are not in every case higher for the necks, but only in two out of the five :—

Neck.	Shaft.
2·20	2·28
2·19	2·29
2·27	2·25
2·20	2·18
2·29	2·32

Hence we conclude that the difference in the difference-figures (10·7 as against nearly 9·0) is not an accidental one, but due to some reason.

For on the Law of Chance it was possible, not to have 5 to 0 all one way, but 5 to 0 against ; and there might have been one exception, and the exception might have fallen out in the following ways :—

1	0		1	0		1	0		1	0		0	1		1	0		0	1		0	1		0	1		0	1
1	0		1	0		1	0		0	1		1	0		0	1		1	0		0	1		0	1		0	1
1	0	or	1	0	or	0	1	or	1	0	or	1	0	or	0	1	or	0	1	or	1	0	or	0	1	or	0	1
1	0		0	1		1	0		1	0		1	0		0	1		0	1		0	1		1	0		0	1
0	1		1	0		1	0		1	0		1	0		0	1		0	1		0	1		0	1		1	0

And there were still more possibilities when the possible arrangements of two exceptions is considered. In short, there were five groups of two possibilities each ; the number of chances possible was therefore 2^5 (two to the fifth power, as we used to hear when at school)$=32$. Therefore, on the Law of Chance it was 31 to 1 against the results panning out as they did, namely, 5 all to one side and none against. And seeing each of the difference-figures is based upon 100 measurements, one is led to the opinion that in the difference between these two sets of figures we were face to face with some purposeful trend or tendency in tissue running counter to the Law of Chance. Surely there was a reason for this. To what other reason than that the neck of the bone bears an especial degree of strain.

So far our preliminary test. We have scaled so far. But just as the alpine climber goes up roped, so let us take further help and test still further.

Accordingly Miss Margaret Scrymgeour of North Berwick carried out some 14,000 measurements on the ancient Egyptian bones lying at Cambridge, while the calculations were made by Mr John Dougall as before.

Five hundred of the thigh bones were broken at the upper or lower ends, but were still measurable for neck and for shaft, the mid-shaft being estimated as closely as possible by the eye. The majority of the thigh-bones were intact, however.

The measurements are set down in centimetres, the size of which is compared with an inch in figure. The numbers for the necks and for the shafts are set back to back for sake of clearness: firstly, the 1085 unbroken bones, then the 480 broken ones.

THIGH BONES.

1st 100.

Neck.		Mid-shaft.
	cm.	
1	1·8	. .
7	1·9	1
18	2·0	13
15	2·1	13
18	2·2	18
9	2·3	19
12	2·4	15
9	2·5	9
8	2·6	10
2	2·7	1
1	2·8	. .
. .	2·9	1

2nd 100.

Neck.		Mid-shaft.
	cm.	
1	1·7	. .
3	1·8	1
8	1·9	. .
16	2·0	2
10	2·1	19
12	2·2	26
11	2·3	18
13	2·4	15
13	2·5	10
8	2·6	7
4	2·7	2
1	2·9	. .

3rd 100.

Neck.		Mid-shaft.
	cm.	
2	1·8	1
15	1·9	1
28	2·0	13
15	2·1	22
17	2·2	21
5	2·3	22
10	2·4	11
6	2·5	7
1	2·6	1
. .	2·7	1
1	2·8	. .

4th 100.

Neck.		Mid-shaft.
	cm.	
2	1·8	1
5	1·9	1
17	2·0	8
22	2·1	22
15	2·2	10
7	2·3	23
1	2·4	16
14	2·5	12
7	2·6	5
. .	2·7	2

Thigh Bones—*continued.*

5th 100.

Neck.		Mid-shaft.
	cm.	
5	1·8	. .
10	1·9	. .
15	2·0	10
13	2·1	26
20	2·2	18
17	2·3	17
5	2·4	15
3	2·5	9
5	2·6	3
6	2·7	2
1	2·9	. .

6th 100.

Neck.		Mid-shaft.
	cm.	
2	1·8	1
9	1·9	8
12	2·0	17
15	2·1	13
11	2·2	16
19	2·3	15
15	2·4	9
8	2·5	15
4	2·6	4
3	2·7	1
2	2·8	1

7th 100.

Neck.		Mid-shaft.
	cm.	
. .	1·4	. .
1	1·7	1
9	1·8	5
9	1·9	10
16	2·0	18
18	2·1	23
15	2·2	12
4	2·3	5
8	2·4	9
6	2·5	3
5	2·6	10
6	2·7	3
1	2·8	1
1	2·9	. .
1	3·3	. .

8th 100.

Neck.		Mid-shaft.
	cm.	
1	1·7	. .
4	1·8	1
9	1·9	3
14	2·0	12
9	2·1	14
14	2·2	15
13	2·3	13
16	2·4	20
13	2·5	16
4	2·6	3
2	2·7	1
1	2·8	1
1	2·9	1

9th 100.

Neck.		Mid-shaft.
	cm.	
1	1·7	. .
3	1·8	1
5	1·9	2
8	2·0	5
19	2·1	13
12	2·2	18
16	2·3	24
12	2·4	17
12	2·5	12
8	2·6	6
4	2·7	2

10th 100.

Neck.		Mid-shaft.
	cm.	
1	1·6	. .
2	1·8	. .
5	1·9	4
8	2·0	8
13	2·1	17
13	2·2	12
9	2·3	17
16	2·4	18
10	2·5	9
11	2·6	6
4	2·7	5
1	2·8	4
2	2·9	. .
3	3·0	. .
1	3·1	. .
1	3·2	. .

THIGH BONES—*continued.*

11th 100 (85).

Neck.		Mid-shaft.
	cm.	
1	1·9	1
1	2·0	1
4	2·1	5
9	2·2	8
7	2·3	15
17	2·4	20
17	2·5	19
13	2·6	9
5	2·7	6
5	2·8	1
6	2·9	..

12th 100 (broken).

Neck.		Mid-shaft.
	cm.	
1	1·7	..
2	1·8	..
5	1·9	..
14	2·0	11
18	2·1	15
18	2·2	17
17	2·3	22
10	2·4	19
9	2·5	12
4	2·6	1
2	2·7	3

13th 100 (broken).

Neck.		Mid-shaft.
	cm.	
1	1·7	..
6	1·8	..
6	1·9	2
15	2·0	7
13	2·1	22
25	2·2	16
12	2·3	18
6	2·4	22
10	2·5	6
4	2·6	6
1	2·7	1
1	2·8	..

14th 100 (broken).

Neck.		Mid-shaft.
	cm.	
3	1·8	..
10	1·9	2
19	2·0	10
18	2·1	14
12	2·2	27
17	2·3	14
9	2·4	26
9	2·5	4
1	2·6	2
1	2·7	1
1	2·8	..

15th 100 (broken).

Neck.		Mid-shaft.
	cm.	
1	1·5	..
1	1·7	..
4	1·8	1
5	1·9	2
10	2·0	9
18	2·1	16
14	2·2	18
13	2·3	15
16	2·4	21
11	2·5	12
6	2·6	5
..	2·7	1
1	2·8	..

16th 100 (broken).

Neck.		Mid-shaft.
	cm.	
4	1·9	..
9	2·0	2
12	2·1	9
15	2·2	25
8	2·3	12
11	2·4	12
10	2·5	9
6	2·6	8
4	2·7	1
1	2·8	2

Next consider the difference-figures calculated for these results. The first thing to note is that the difference-figures at the upper end, the neck, are higher than those for either the middle or the lower end of the bones. This may be tabulated thus :—

	Neck.	Shaft.	Lower End.
1st 100	10·1	8·7	9·0
2nd 100	11·3	7·5	7·9
3rd 100	9·3	7·3	8·3
4th 100	9·6	8·2	8·0
5th 100	11·0	7·7	7·6
6th 100	10·2	9·7	8·9
7th 100	13·3	11·8	11·2
8th 100	10·8	9·2	8·6
9th 100	10·2	7·8	8·2
10th 100	12·9	9·7	10·0
11th 100 (85)	9·0	7·2	8·2
Average	10·7	8·8	8·7

So that while the difference-figures for mid-shaft and lower end are sometimes lower and sometimes higher, and come out on the average practically identical, the difference-figure for the neck is appreciably higher all through.

In addition, these are the figures for the broken bones :—

	Neck.	Shaft.
12th 100	9·3	7·5
13th 100	10·2	7·7
14th 100	9·6	7·1
15th 100	10·4	8·1
16th 100 (80)	9·8	7·8
Average for five	9·8	7·6

The important point about all this is not the difference between the calculated figures for neck and shaft, but the fact that the difference is *always and without exception* on the one side higher for the neck. The difference-figure for the neck of the bone

exceeds that of the shaft in 16 out of a 16 possible: on the Law of Chance this would give us a 2^{16} (two to the sixteenth power) number of different possibilities, *i.e.* no less than 65,536. The chances, therefore, against these results being accidental are as 65,535 to 1. Hence it appears that these thigh bones possess a tendency that cannot well be explained on the Laws of Chance, and must therefore indicate a purposeful trend in the lives of the ancient Egyptians measured.

A glance at the diagrams for the second hundred will do more than pages of explanation to indicate that a typical difference-figure means an extension of a series to opposite sides of a mean-value.

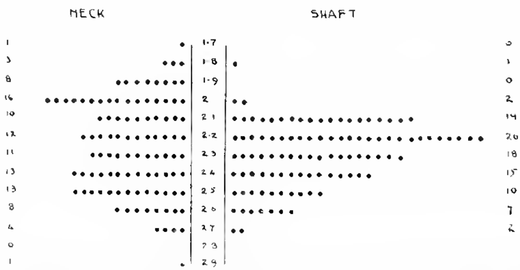


FIG. 260.—Units of the 2nd 100 thigh bones measured for neck and mid-shaft, and the measurements arranged back to back in centimetres.

The greater aggregation of the shaft figures about the mean is best seen by regarding the figure sideways.

The actual figures for neck and shaft are plotted out back to back for each hundred.

Various Objections.—It may be objected: This is all very well, but there is no difficulty in seeing how the difference-figure for, say, the neck of the thigh bone (the part bearing a special strain) is higher than that for the shaft; some of these Egyptians were fatter and heavier than others, and of course the weight of a heavy man will fall specially heavy on the neck of his thigh bone, which (though thinner than the shaft to begin with) would then in a certain number of cases thicken against the strain it had to carry; therefore, over a series of necks and shafts there will be a number of specially thick necks (corresponding to the heavy men), and these high figures will extend the range and pull up the difference-figure for the series of necks over that for the shafts.

This objection is a shrewd thrust, but it fails to meet the facts.

The neck of the thigh bones is not thin to begin with, but on the average thicker than the shaft. Thus in 87 young bones (from very young up to 15 or 16 years) the measurements for neck and shaft were :—

Neck.		Shaft.
	cm.	
..	1·0	1
..	1·1	7
..	1·2	2
3	1·3	10
2	1·4	6
9	1·5	11
8	1·6	11
10	1·7	11
12	1·8	10
19	1·9	6
6	2·0	6
4	2·1	6
8	2·2	2
5	2·3	..
7	2·5	.. *

Secondly, if the higher difference-figures for the neck in adults were due to the inclusion of a number of specially thick necks, the average values (M) for the necks should be higher than those for the shafts. But the contrary is the case :—

* Eighty-seven bones are not enough to rest any definite conclusion on, but these figures are of interest to the problem of heredity (*cf.* p. 113). The expectation was that the difference-figure for the neck would be as in the adults higher for the strained part, the neck, thence for the shaft. But the actual figures are just the opposite :—

	Mean.	Difference-figures.
Neck . . .	1·84	14·3
Shaft . . .	1·60	18·2

Now, why are the units of this series of young bones thus grouped more round the mean at the necks ? Why this retention at the point of special strain ? Is it not because the child's thigh bone is, so to speak, screwed up against what it has to meet during life ? This screwing up was inherited from the strain upon the thigh bone of the ancestors—*a strain that could occur only during life.* Hence strain in our ancestors is transmissible to ourselves, strain in ourselves is transmissible to our children. Man is compensating not merely against past events and present conditions, but also against future needs. The point merits further attention.

	Mean-values for	
	Neck.	Shaft.
1st 100	2·23	2·29
2nd 100	2·25	2·29
3rd 100	2·13	2·22
4th 100	2·22	2·28
5th 100	2·20	2·25
6th 100	2·24	2·23
7th 100	2·19	2·18
8th 100	2·23	2·28
9th 100	2·26	2·30
10th 100	2·34	2·31
11th 100	2·47	2·40
12th 100	2·22	2·28
13th 100	2·19	2·27
14th 100	2·18	2·25
15th 100	2·23	2·27
16th 100	2·28	2·32
Average for sixteen	2·24	2·28

In only four out of the sixteen possible is the mean for the neck higher than that for the shaft, so that while the mean-figures for the neck are lower, the differenee-figures for the neek are higher ; thus :—

	Mean-figure (for 16 hundreds).	Difference-figure (for 16 hundreds).
Neck	2·24	10·4
Shaft	2·28	8·3

Now, if the differenee between neck and shaft in the thigh bone had been due simply to some heavy Egyptians having possessed thicker necks in their thigh bones, then obviously these thicker necks would raise the average-figure for the necks above that of the shafts. That is pretty elear. But as the average for the neeks is not higher, but *lower*, than that of the shafts, we may conclude that the higher differenee-figure of the necks is due not to the series spreading out in one direction, but to the series spreading out to opposite sides of the mean-value of the series. That is a divergence of the series away from and to opposite sides of the mean.

This result is important. Although at first sight it would not seem to matter a jot what size any bone or series of bones might be, no new fact—however apparently useless—should be neglected. For

a new fact may be the germ of a principle, the principle of a law. The law assists us to discover more and truer things. Never weigh a harvest in spring; never count your chickens before they are hatched.

Having now reached a summit, namely, the fact that at the point of a bony tissue where strain is greatest there the divergence of the tissue is also greatest, let us next inquire *how*, or *on what principle*, the neck of the tissue changes, and whether its changes are passive or active. Let us proceed now to that inquiry, indeed the one we started from.

It being impossible to solve Passivity *versus* Activity by absolute proof, which would necessitate absolute isolation of the matter under

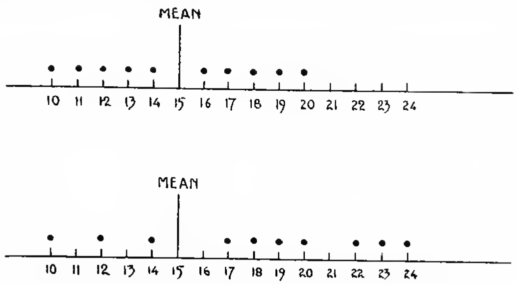


Fig. 261.—Illustrating a divergence, but not to opposites of a mean.

test from its surroundings—and such an absolute test is naturally impossible—we are obliged to proceed by way of reasoning, and best by way of question and answer.

Q. What is found ?

A. A definite relation between the special strain within a part of a bone and the difference-figure at that part—that is, between special strain and the extent to which that part of bone has changed.

Q. What form does this relation take ?

A. The difference-figure is increased—that is, there has been a divergence away to opposite sides of the mean-value of the part measured.

Q. Could the relation have taken any other form ?

A. Yes. The difference-figure could have been increased—that is, a hold towards the mean-value of the part measured.

Q. What is the meaning of a divergence to opposite sides of the mean-value in the case of a bone ?

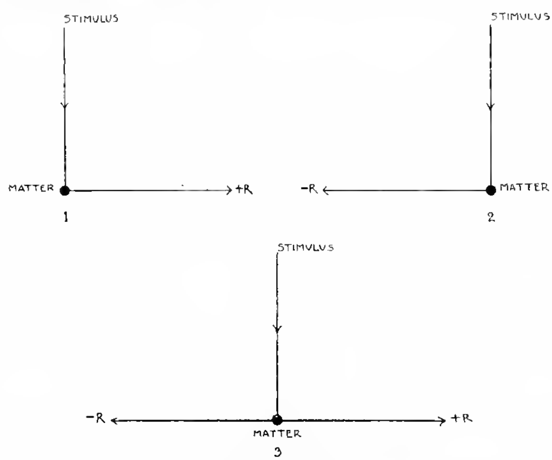
A. It means that the higher measurements are higher and the lower measurements are lower at the point of special strain.

Q. Does this increased lengthening *and* diminished shortening in a series of bones indicate whether the bones are passive or active ?

A. Such extension of a series in opposite directions indicates activity in the units of that series.

Q. How so ?

A. For if strain acted on a certain point of a bone, and we found our whole series of measurements longer (+) at this point, this might be a passive result ; or if we found the whole series of measurements shorter (−) at this point, this might be the passive result of a passive change. But when we find the bones responding to strain, some in the one direction, *i.e.* increased lengthening, and some in exactly the opposite direction, *i.e.* increased shortening, *there must be some internal active factor which is translating internal strain set up in the bones and expressing it in two opposite directions.*



FIGS. 262, 263, and 264.—To illustrate the action of matter in opposite ways at the same time.

Or to place the facts in diagrammatic form, let M be the reacting form of matter (in this case bone), S the exciting action (in this case the weight on the neck of the bone), and R the reaction.

Now, if reaction of the series of units in question were all in the direction of thickening or plus, as in (1), the reaction might be considered a passive one. Or if the reaction were all in the direction of narrowing or minus, as in (2), the reaction might be thought of as passive. But if the body M throws out the effects of strain *in two exactly opposite directions* towards plus *and* towards minus, as in (3), there must be some internal activity within the body M to account for this. Any other consideration is impossible to the human mind.

The Law of Activity in Matter.—Hence there lies within the bones some transforming activity beyond the reach of scientific measurements. For while we can hope to estimate a quality in matter that over a series of units reacts either in one direction or in another direction, it altogether baffles the mind to estimate in precise and finite terms a quality that transforms a strain in two directions opposite to each other. That quality is activity. Hence the evidence of activity is stamped upon these ancient Egyptians' bones, and as there appears no reason for dissociating the ancient Egyptians in quality of humanity from ourselves, we attain the following conclusions :—

1. The human bones possess some internal quality which can be comprehended by the mind but cannot be expressed in the finite terms of our modern science. The human bones show evidence of activity. Hence
2. The form of matter, man, is active. Hence
3. All matter is active, for if one form of matter has evolved from another form, it is inconceivable that one form of matter could be active and another passive : passive matter could not conceivably grow and evolve into active matter. Hence
4. It is possible to formulate a Law of Activity, to interpret Matter in all its changes.

The Law of Activity.

1. Every form of matter is active and eternal.
2. Like causes never produce like effects. Every action is different. Every change is new.

   Action and Reaction are unequal.

   There is no such thing as a Reflex.

The Law of Causation ("the qualities of organisms are the necessary consequence of definite causes") is incredible.

3. No aspect of matter is ever identical at any two successive moments of time. The equipoise of any form of matter is never, for any one second, at absolute rest.

    Every form of matter is trending.

    Every spectrum is constantly varying.

4. Matter changes from within; holding or diverging. Motion emerges.

    The motion of a body, such as a rolling ball, is the strain of the body in a form visible to our senses.

5. Matter moves in moving matter.

    Bodies exert free action even within a continuous medium.

6. The individual man is, primarily, an independent being, but is influenced by the activity of his neighbours.

The reader may choose from these fourteen definitions the one he likes best.

This law meets the tests of John Herschel and of Herbert Spencer:—

> "The grand, and indeed only, character of truth is its capability of enduring the test of universal experience and coming unchanged out of every possible form of fair discussion."

> "The deepest truth which we can get at must be unaccountable."

Activity is too simple to be fully understood.

Summary of Step 9.

A consideration of measurements made by Alfred Russel Wallace upon certain birds leads to a guess on the action of strain. The Strain of Inbreeding then reviewed.

A number of tissue-units (bones) representing a large number of ancient Egyptian men and women are tested, and on different parts of the bones being compared these facts emerge:—

1. There exists a relation, not accidental, between strain and the extent a tissue diverges from the average.

2. Tissue-divergence in response to strain expresses itself to opposite sides of a mean-figure.

As a tissue which reacts in opposite directions cannot be other than active, it follows that matter at one link in the chain of nature has been proven active.

If in one link of the chain, then in all.

Hence the law of activity or freedom of matter.

TENTH STEP.

LIFE OF MAN.

And with respect to the scale of human value, it follows from the law of activity that no individual is merely a more or less complex tissue-unit. Each man, woman, and child, no matter how poor or sick or debased or outcast, is reckoned a free, infinite, unique and irreplaceable Worth—responsive—but of unpredictable possibilities and self-determining power.

Which conclusion predicts and ensures for the life of mankind a higher value than it has hitherto attained.

Part III

THE OUTLOOK

SUMMARY

THE OUTLOOK

" If I had more time, I could have made it shorter," was the bishop's reply to Queen Anne on being rallied on the length of a sermon. Equally so with writing, which one may define as an unconscious or deliberate transgression of reserve. The more unconscious, the more natural its expression. The simpler and more easily read, the better for all of us ; seventy years is too short a time for deciphering hieroglyphics. The main difficulty in writing is to find something to say. Socrates professed to know nothing, and was claimed by the oracle as the wisest of men. Yet there is another side to the shield. Public opinion gains by the loss of fear. You know your work imperfect, halting, tentative ; you know that five, ten, twenty years hence you would strip and tear away three-fourths of your essay to the improvement of the remainder, as did the ancient Sibyl in Rome. To defer is a sure wisdom, yet it indicates a certain lack of trust in your audience.

Accordingly, risking the charge of impetuosity, let us adventure to apply the conclusion and law already attained to one or two problems of modern society—tissue, body and surrounding—the cancer difficulty, the provision of houses, a humble observance of the body in which we move and breathe our being, the harmony of children.

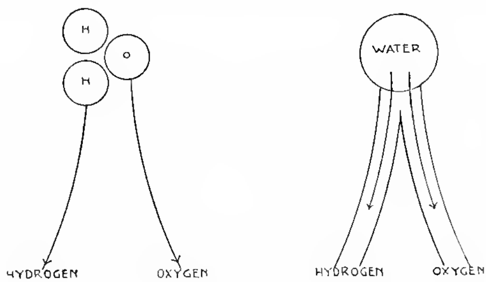
It may be that some reader will find no interest in these special directions. In that case, ladies and gentlemen, you had better go your own gait and apply the principle of activity in the direction you consider best. You now stand equally with the rest of us upon the summit of the ridge, and are free to choose and enter into any opening you favour. There are innumerable to explore. Let us peer out in open silent wonder, as once did Cortez down over the Pacific. There is room for single departure. We can rejoin each other upon mutual desire, and to report and reckon progress.

But one thing is very certain. The grains of discovery already attained are but as nothing to the continents that still remain. Steam and electric power are but a poor show for 2000 years A.D.

THE GROWTH OF WATER.

To take and apply the law of aetivity to the manifold detail of elemental ehemistry is impossible. All we can attempt is to indieate the differenee between the ordinary view and the new one whieh the view of activity unfolds.

Take water, perhaps as simple a body as we can hope to meet. The present idea is that water is built up of three atoms, two marked



FIGS. 265 and 266.—Water. Passivity *versus* Activity.

H in the diagram and one marked O, two of the gas hydrogen with one of the gas oxygen ; and when water is disassociated by the passing of electric shoek through it, the water resolves into its two united gases, hydrogen and oxygen.

But on the view of aetivity water, when shoeked, is stimulated to diverge in two main directions, into the form

1. Of a light gas, " hydrogen " ;
2. Of a heavier gas, " oxygen."

But the " hydrogen " and the " oxygen " are to be regarded as two states of water, as

Water (hydrogen) ;
and Water (oxygen).

THE ORIGIN OF CANCER.

Cancer in common experience is a ghastly and baffling thing. It is almost an immortal disease. It is a fungus-growth accompanied by much agony, both of body and mind. It occurs more frequently than is generally suspected. The Registrar-General's Report on the census of 1911 states that of those who reach the age of thirty-five, one man in ten and one woman in seven in England, Scotland, and Wales die of this strange affection; while in the United States there were recorded 54,584 deaths from cancer in 1915, being at the rate of 81 per 100,000 of the population.

Plate IV. is a microscopic section of a cancer of the tongue. The muscle bundles (*m*) are being eaten away by the cancer cells (C). In appearance the growth often stretches out into the rest of the body, like the animal from which it derives its name, "Cancer," or the Crab. The first cancer often shreds little particles into the blood-streams, which bears them away to invade other parts; sometimes indeed it is these second cancers which first attract the attention of the people affected.

Pains are usually imaginary. But a woman one day feels a slight pain in one of her breasts. She recks little of it. The pain disappears for a time; it then returns slightly. One day she feels a little hard lump. A portion of the body has somehow changed into a destructive yeast of the worst kind; this yeast divides away, and parts of it are carried by the lymph and blood-stream to other parts, to the glands, to the skin, to the bones, to the lungs, and there they live off their own body like parasites selfishly destroying everything and multiplying indefinitely. If the patient were not providentially removed in other ways, the disease might be thought of as developing until the whole body transformed into a perambulating fungoid mass.

Now, what is the nature of this change? That is the point. Clearly there has been an increasing tendency of the tissue to change. This is obvious, because the normal tissue has altered into cancerous. But what has been the method of this change?

Here we are met with a confusion of ideas, for we find the experts holding diametrically opposing views, which cannot both be right. They may briefly be summarised in this way.

1. Cancer has a cause,
2. Cancer has no cause,

which distinction can be expanded as follows:—

1. In this case we look upon the body as a test-tube, varying in response only to the external environment. And naturally if we have this idea, we shall try to explain the development of cancer in terms of the external environ-

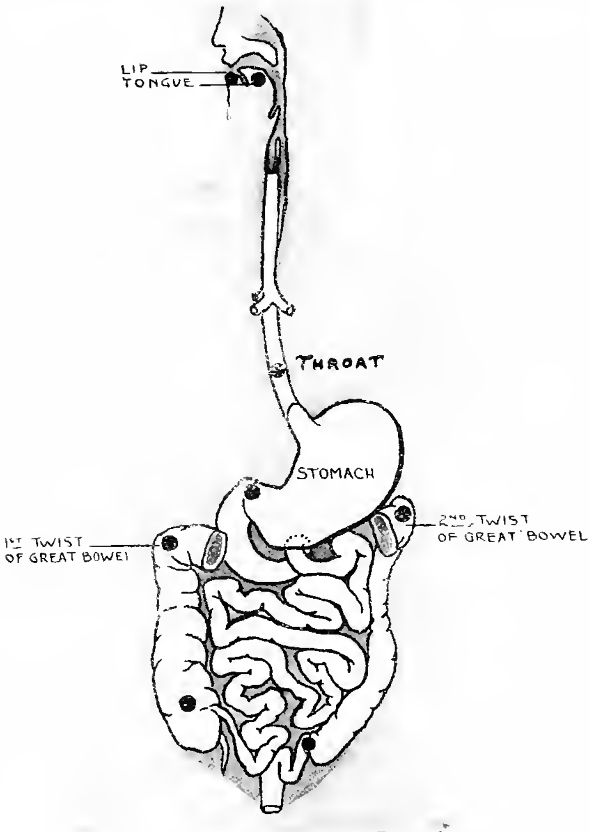
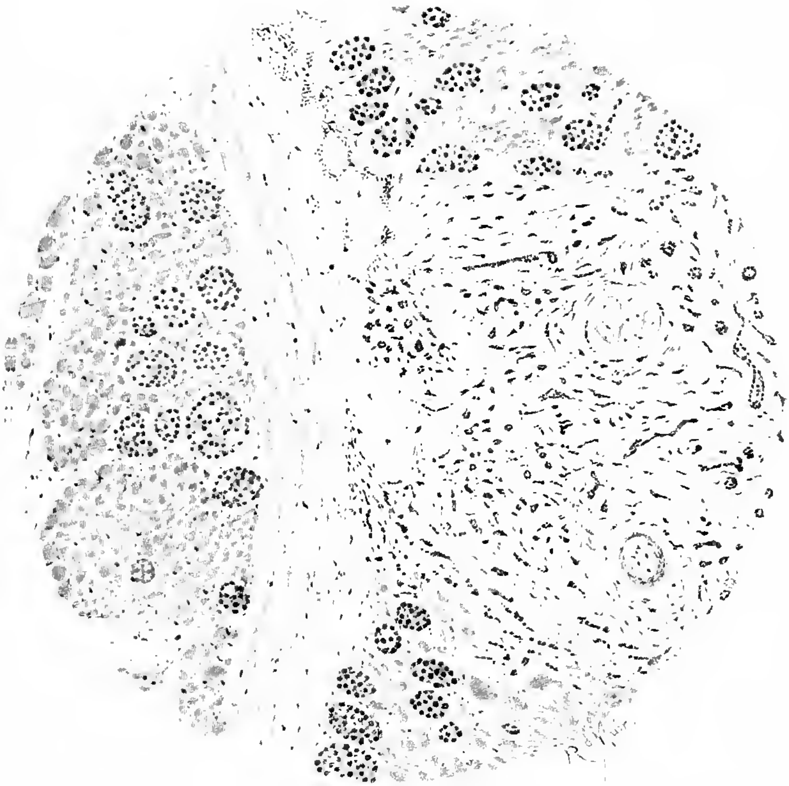


FIG. 267.—Parasite or microbe theory of cancer.

The commonest seats of the disease are supposed to be the twists of the food-track where the microbes stick most readily (marked with black spots).

ment. We shall regard the cancer change as the effect of the action of parasites or some other convenient label. We shall point to the tubercle bacillus as causing consumption, and to the leprosy bacillus as causing the tumour masses of leprosy. We shall discover ultra-



(Drawn by Richard Muir, Edinburgh.

Cancer (blue) invading muscle of breast, (red) magnified 80 times.

microscopic bacteria of many varieties, we shall describe cases in which one person passed on cancer to another, we shall prove the existence of cancer houses in which the family was struck down. Thus the British authority William Macewen points out that cancer affects chiefly the bends of the digestive tract, or wherever the supposed external parasite will impinge, *e.g.* at the lip, tongue, lower ends of gullet and stomach, at the commencement of the great bowel and at its hepatic, splenic, sigmoid, and rectal twists, at all of which points cancer is alleged to occur with especial frequency, while the French expert E. Doyen claimed—as a number of others had already done—to have discovered the actual parasite and pest. On this idea, therefore, a cancer is something foreign to and distinct from the body.

2. In this case we shall look upon the body not as varying in response to external causes, but as diverging from within. We shall hold cancer a phase, not a disease. We shall regard it as compensatory in every case. We shall know it to be non-infectious. We shall find a complete series of tissue-divergences from the benign galls, warts, and polyps to the most rapidly fatal cancer. We shall believe not merely that there are men and women diverging into cancer to-day, but that there are many who have diverged in its direction to recover themselves, and many who are to-day unconsciously curing themselves from within. A tissue-divergence curing itself as a tissue-retention.

These two contradictory alternatives represent the root problem of the change of tissue into cancer.

This difficulty is still unsolved; as Oscar Hertwig remarks, "Whether the different kinds of cancer are of parasitic origin remains still a questional problem" (*General Biology*, p. 488).

Let us briefly relate the way we come to consider the question here, stating :—

1. One or two observations.
2. The application of the law of activity to the problem.

1. At first sight there seems a considerable difference between a simple wart on the nose or the hand and such a destroying growth as in the illustration. Yet it is not easy to draw any sharp line

between the two. For there are a certain number of growths of an intermediate character, partaking of the quality, both of a simple and innocent growth, and of a dangerous and fatal one.

Thus, a young man received a blow on the forehead with a cricket-ball. After the injury the bone of the forehead started to grow, and knobby masses of bone were removed on separate occasions. Operations were required, because the bony masses grew continuously; they made their way inwards towards the brain, and gave rise to epileptic fits. The bone had lost restraint, so to speak. And surely, if a tissue continues, in spite of treatment, to grow, it can scarce be called wholly simple and innocent in nature. We, therefore, drew

(After J. E. Erichsen.)

FIG. 268.—Cancer of the lip in a man of twenty-one years.

the conclusion that there exist growths on the border-line between a simple wart and a deadly cancer.

The next step was this :—

In the summer of 1910 the American surgeon William H. Mayo made the remark, " The only thing known to cause cancer is chronic irritation." And certainly this appeared correct; the clay pipe rubbing on the lip may end in a cancer on the lip, a jagged tooth rubbing may elicit cancer of the tongue, a blow upon a breast or a kick upon a bone has been known to start the disease, in earlier days chimney-sweeps sometimes developed it in their skin owing to irritation by soot—" chimney-sweeps' cancer "; moreover, the natives of Cashmere attach the ropes of their wagons to the right horns of their cattle, and it is generally in the right horn that cancer grows. The question at once obtruded itself, What is the nature of the change occurring in the tissue intermediate between the irritation (the cause) on the one hand and the cancer (the effect) upon the other?

A little later, in the spring of 1912, the Berlin specialist, von Hansemann, said casually in an aside to a lecture upon the cause of cancer, "Of course you must recollect one thing, cancer has already been produced experimentally in man," he paused and continued—"by means of the X-rays." This was true; some of the earlier workers on the Röntgen rays had exposed their unprotected hands to the action of the rays, and their fingers, hands, and arms had gone into fungating ulcers of a cancerous type so as to require amputation: refer to fig. 88. Otto Hesse in 1911 published a record of 54 such cases in X-ray workers—26 in America, 13 in England, 13 in Germany, and 2 in France, of an average age of forty-two years. He states that in Macdonald's San Francisco case, in Fowler and Wiley's Brooklyn case, and in others the cancer spread to the glands of the armpit and thence to the chest, resulting in death. But not alone the X-rays, but other irritation, for example, heating, have accompanied cancer, as in certain Indian fakirs carrying live coals in immediate relation to their skin.

The conclusion obtruded itself: The way to tackle the cancer question is not to make experiments—these have already been carried out by the X-rays—but to work down to the heart of the difficulty, namely, to determine the nature of the internal change at work within the tissues.

With this clue in hand the inquiry was pursued somewhat after this manner:—

Question. What is known about cancer?
Answer. The following equation:—

Chronic Irritation and Strain = Cancer.

Question. But surely not all at once! Are there no intermediate step or steps?

Answer. Like enough there are such steps.

Question. Well, then, shall we start from the cancer side or from the strain side of the equation?

Answer. From the strain side, for there are fewer workers there.

Question. Strain? Are there any points in the normal human body where strain falls specially heavy?

Answer. Yes, at the neck of the thigh bone.

Question. Well, why not measure the necks of a number of thigh bones to see whether or not there is any numerical difference between this part and the other parts of the bone?

Answer. There is a difference. The figure of change for the neck of the bone is 10·7, at the other points of the bone only 8·7.

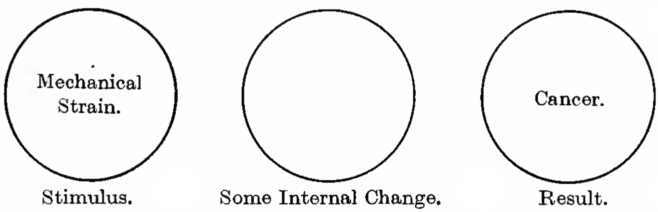
Question. What inference can be drawn from that ?

Answer. That *there exists a relation between the strain which a tissue bears and the extent to which that tissue diverges towards an extreme.*

Question. But admitting this principle to apply to hard tissues, such as bone, can we consider it equally applicable to soft tissues, such as the breast of a woman or the tongue of a man ?

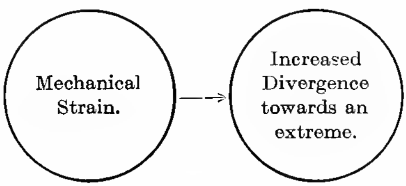
Answer. Where there is a will there is a way. Bones are just soft tissues fixed by salts of chalk.

2. To come now to the application of this principle. Take the case of the tooth rubbing on the tongue, for instance. What have we ? In diagrammatic fashion the sequence runs thus :—

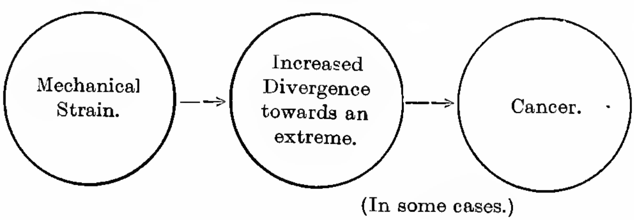
(1)


The middle circle is unknown, and is the heart of the cancer problem.

The effect of mechanical-strain upon the normal tissues is found to be :—

(2)


Therefore, taking this result for the hard tissues and substituting it to fill in the vacant circle there transpires :—

(3)


This research did not succeed in measuring the divergence of tissue directly into cancer. But it clears away the first difficulty confronting any solution of the cancer problem, namely, the understanding of how it arises. For from the standpoint of active divergence one sees, say, the tongue straining gradually away from type till it becomes what we call "cancer." *There is thus no cause of cancer—the actual divergence, the actual straining and struggling of the tissue, the actual change—that itself is the cause.* If you see that, you grip at a flash the meaning of cancer; if you do not see it, then wait till, like looking on a picture, it suddenly opens upon your senses. Cancer is an actual thought of the body, an over-selfish inflammation.

From which it follows that the disease is in no respect and under no circumstances infectious, in the sense that a parasite-disease such as consumption is infectious.

The active or "divergence-hold" interpretation of the cancer riddle can be applied to the facts at present known in the field.

On the score of Divergence it allows for the widespread occurrence of cancer in both plant and animal kingdoms. It covers the sudden explosions of malignancy which kill inside of weeks; as well as these lingering cancers, the hard growths, occurring, for example, in the breast, which may last over ten years. Slow divergence and hold explains such a case as in the experience of Alfred Pearce Gould. In 1890 the left breast of a woman was removed for a typical cancer, microscopically diagnosed. In 1895 she was ill and emaciated, the disease having invaded her skin and the glands of the armpit and neck on both sides; there was also a cancerous fracture of the neck of the left thigh bone, due to shreds of the growth being carried thither and eating the marrow of the bone away; but between March and November 1896 the skin growth shrank and changed into scars, the glands subsided, the fractured bone united, and all evidence of growth disappeared; the health of the woman improved, and by 1899 all the scars were soft and supple; death occurred as late as 1906. Here the woman diverged so far into cancer, then went into a state of hold and cured herself; the disease swept forward so far, then was balanced and restrained by the body and pressed back for many years. Temporary abatements and the later recurrences have also been noted by Hector Cameron; they may be described as Holds followed by later Divergences.

As a multiple divergence the principle elucidates how cancer sometimes develops in several members of one family; and as a

hereditary divergence it accounts for cancer erupting about twice as often in mice with a recent cancerous history among the ancestors as in those where only the remote ancestors were affected.

Experimental facts can readily be grouped under the principle, for instance, the observation of the German Paul Ehrlich, made on a mouse, that a cancer can still diverge and grow after a two years' refrigeration. Or the experiment of Alexis Carrel and Burrow that a piece of cancerous tissue grew to twenty-two times its original size after it had been transplanted to a nourishing fluid outside the body. Or again, how the deadly virulence of a cancer growth can at times be increased by " straining " it through a series of animals from one animal to another, or how a typical cancer may diverge to become what was formerly thought a different kind of growth known as " sarcoma."

And without attempting to belabour the subject, let us refer back to fig. 240, illustrating how internal strain may act independently of direct external stimulus, and we readily understand such cancers as occur in the breasts of young unmarried women without any particular cause. These are spontaneous divergences.

On the score of Retention, on the other hand, we grasp how a growth may go back on itself in self-cure. We comprehend how mouse cancers exposed to the cold of ice did not grow so rapidly as normal temperature specimens. We perceive also how the action of radium, or the combined action of radium, X-rays, and heat, may stimulate the tissues to go back on their previous divergence and to hold further, and how by electric shock to the tissues—as carried out by Doyen of Paris—they may move from their diverging line back towards the average or mean of the tissue.

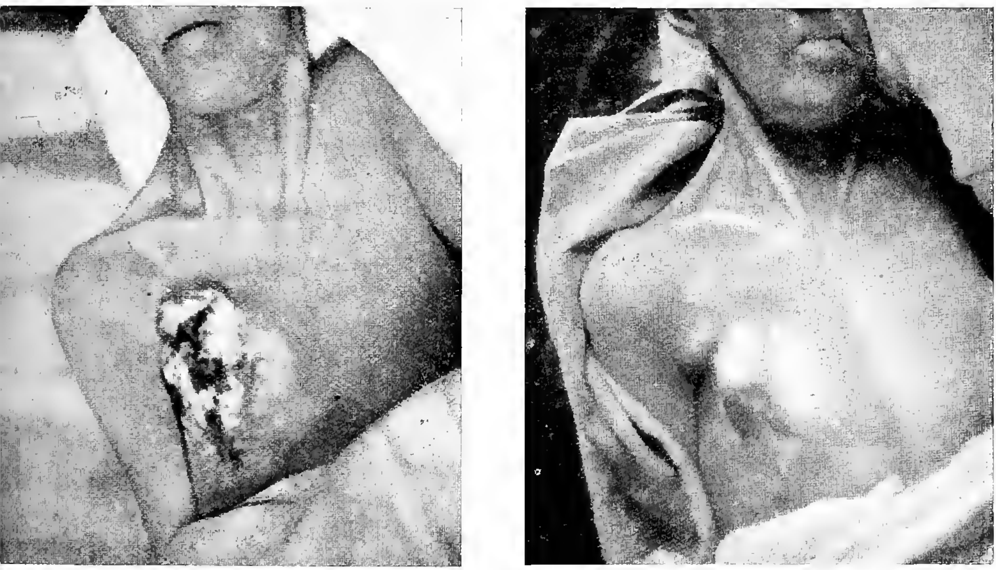
We can also see how a cancer carried away in the blood from the restraining influence of the first affected locality may grow more rapidly even than the first cancer itself.

Both in man and in experimental tumours cancer grows in alternating waves not wholly devoid of rhythm. This difficulty clears up on the divergence-hold principle of growth. Other perplexities can also be cleared up, how that portions of the same cancer injected into a number of mice flourish in some, disappear in others, and in others again recede at first and then advance.

So much for the origin of cancer. *It has no cause.* Every day in our community individuals are diverging into cancer unconsciously, and as unconsciously curing themselves in hold.

The strange quality of compensation, evinced in the active

divergence of cancer, is not confined to that disease, but is happily a constant sojourner in human affairs. Every cloud has its silver lining. Joyful fortune lightly steps towards us behind the shield and mask of adversity. Our losses of kindred, our cares and sorrows, our business worries, the struggle to make ends meet, the strange and funny stupidities, the superciliousness of the uppish or the man who seeks to set his bulky vat on its own bottom, the weaknesses of the body, the everyday wear and tear, the deadly insupportable



(After W. F. Somerville, Glasgow.)

Figs. 269 and 270.—Cancer in hold.

Temporary abatement in a woman of seventy-one years after exposure to X-rays.

dulness of some things—they are one day made good. Courage! give it time—Rome was not built in a day; to err is the proof of humanity; as in the Lett proverb, a thing slow done is well done. The clouds may go surging black across the zenith of our hopes, but there, towards the horizon, the brighter shafts of light are ranging to the sea. And before long, before long we shall see clear and limpid, and the tears will dry as off the face of a child, and the flicker of a smile will gladden our cheeks to others.

But this is digression. The quality of compensation merits attention. John Hunter met it in the stag, for he tied the carotid

artery supplying one of its antlers. The antler became cold, but in a week's time he was surprised to find it warm again. And on killing and examining the stag he perceived other neighbouring arteries had enlarged, taken on the duties of the big one, and were sending up the blood. And the strain of cancer also contains such an element of compensation; in its peculiar way it tries to meet a want felt by the body.

But there still remains the directly practical question, How can we damp down the present rate at which men and women are diverging into cancer? Now, the surgeon's knife has often proved to the assisting of Nature and the saving of life in the past, and although no one seeks operation for its own sake, it is often desirable to get rid of the diverging area by cutting it out; and usually to discover early is better than to discover late. For no one remedy will in *every* case turn a divergence back into a hold; for what is slow in origin is often slow in cure; and there will always be some people in which the remedy will excite, not, and as intended, a hold, but an even more rapid divergence of the cancer growth. We cannot, therefore, dispense altogether and immediately with the surgeon's knife.

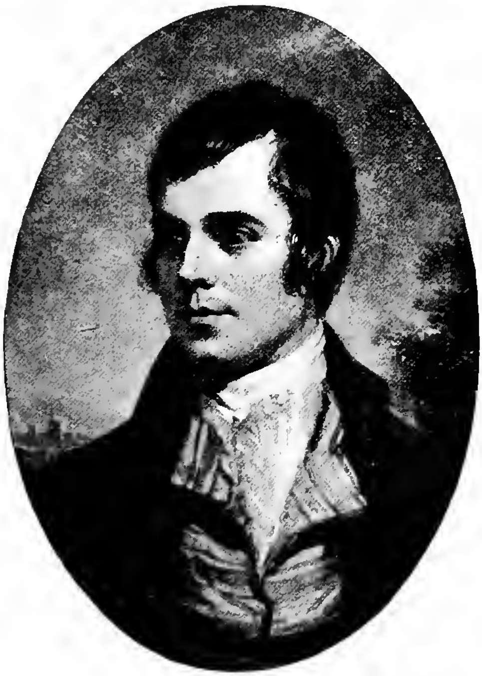
But the question still obtrudes itself, How can we bring about this Hold and postpone the period for cancer change in a man or woman's life—for no one worries much how he is removed at the last, if he has done his bit of work. The answer to this question depends on a fuller inquiry, and involves a more thorough testing of the natural surroundings of water, air, sun, and cream than can be undertaken by the limited resources of a single individual.

This chapter is entitled only "The Origin of Cancer," and just as we rid a wasp of its sting by capturing first its bike, so we cannot experiment with any hope upon the cure of cancer till we grasp its origin.

Cancer has arisen in one environment, that of air. To experiment upon affected individuals with a totally different environment, that of warm water and electro-magnetic action, for instance, would mean the sojourn of a number of individuals for months in water-baths. A rich and young land, such as America, will have to deal with that problem. Or Britain when it is young again.

LAND AND HOUSES.

Youth is the time for receiving impressions. The memory is then more resilient. That is perhaps why the old remember early events better than the late ones, and why the long past flashes across the vision of a drowning man, and even a stray word or look may exert a most enduring influence upon the boy or girl. Rosaline Masson



(*After Alexander Nasmyth.*)

FIG. 271.—Robert Burns.

has described the meeting of two famous Scotsmen in such a way as to illumine this brightly :—

> " In 1786 thus occurred the memorable meeting, at the house of Professor Adam Fergusson, between Burns and Scott. There was a gathering of ' several gentlemen of literary reputation,' and Scott, a boy of fifteen, was present. Scott ' had sense and feeling enough to be much interested in his poetry, and would have given the world to know him,' but, with the

better manners of that period, 'of course we youngsters sat silent and listened.' Burns was affected by one of the pictures on the wall and the lines printed beneath it. He 'actually shed tears,' and asked whose the lines were. None of the 'gentlemen of literary reputation' volunteering the information, Scott whispered to a friend that they were Langhorne's, and the friend told Burns, who turned to the boy with a 'look and a word.' 'You'll be a man yet!' is what Burns said; and those words and that look are all the link between these two great Scottish poets, who 'spoke each other in passing.'"

Infant Mortality.

Let us preface any reference to the subject of land and houses by noticing the mortality among infants. Remembering, too, that Isaac Newton—no greater name in science—was born a premature and posthumous child: "The helpless infant thus ushered into the world was of such an extremely diminutive size, and seemed of so perishable a frame, that two women who were sent to Lady Pakenham's, at North Witham, to bring some medicine to strengthen him, did not expect to find him alive on their return."

Scotland may be taken in illustration of the ages at death, both male and female. These were in 1913:—

Age Groups in Years.		Age Groups in Years.	
0	13,214	35	5,092
1	7,133	45	6,522
5	1,833	55	8,762
10	1,180	65	11,113
15	3,371	75	10,903
25	3,940		

This indicates that the mortality rate is highest during the first year after birth. One infant in nine born fails to survive the first year. The figures in several towns, counties, and countries are these. For the majority of the town figures the reader is indebted to the courtesy of the respective medical officers of health.

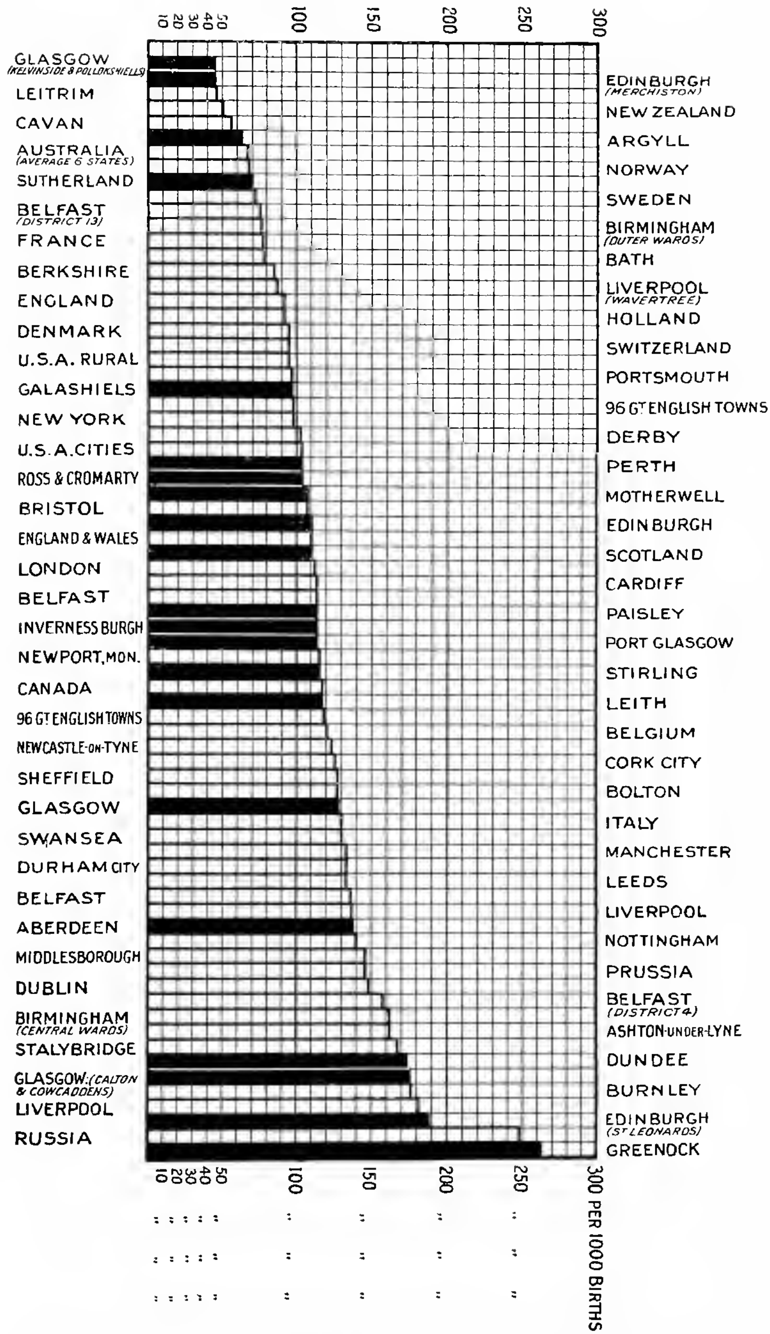


Fig. 272.—Infant mortalities per 1000 births: Scottish figures shaded.

Deaths under One Year per 1000 *Births.*

(The figure 10 refers to the decade 1907–16.)

The figure for France excludes infants which die before the third day :—

Glasgow (Kelvinside and Pollokshields), 1913	45
Edinburgh (Merchiston, 1914)	45
Leitrim, 1915	46
New Zealand, 1915	50
Cavan, 1915	56
Argyll, 1915	63
Australia, 1915 (average six States)	67
Norway, 1914	68
Sutherland, 1915	70
Sweden, 1911	72
Belfast, 1916 (District 13)	76
Birmingham (average 1912–16), Outer Wards	77
France	78
Bath (10)	79
Berkshire, 1915	85
Liverpool (10), Wavertree	87
England, 1916	91
Holland, 1915	91
Denmark, 1913	94
Switzerland, 1912	94
U.S.A., Rural, 1915	94
Portsmouth (10)	97
Galashiels (10)	97
Ninety-six great English towns, 1916	99
New York, 1915	99
Derby (10)	102
U.S.A., Cities, 1915	103
Perth (10)	103
Ross and Cromarty, 1915	103
Motherwell (10)	108
Bristol (10)	108
Edinburgh, 1914	110
England and Wales (10)	110
Scotland, 1914–15	110
London, 1915	112
Cardiff (10)	113
Belfast, 1916	113
Paisley (10)	113
Inverness Burgh (10)	113
Port-Glasgow (10)	113
Newport, Mon. (10)	115
Stirling (10)	115
Canada, 1913	117
Leith (10)	117
Ninety-six great English towns (10)	119
Belgium, 1912	120
Newcastle-on-Tyne, 1912–17	123
Cork City (10)	126
Sheffield (10)	128
Bolton (10)	128
Glasgow, 1913	129
Italy, 1912	130
Swansea (10)	130
Manchester (10)	133
Durham City (10)	133
Leeds, 1906–16	133
Belfast (10)	136
Liverpool (10)	137
Aberdeen, 1911–16	138
Nottingham (10)	140
Middlesbrough (10)	146
Prussia, 1912	146
Dublin, 1907–15	149
Belfast, 1916 (District 4)	158
Birmingham, 1912–16 (Central Wards)	161
Ashton-under-Lyne (10)	161
Stalybridge (10)	167
Dundee (10)	173
Glasgow (Calton and Cowcaddens), 1913	175
Burnley (10)	176
Liverpool, 1916 (Exchange)	181
Edinburgh, 1914, St Leonards (density 351 per acre)	189
Russia	248
Greenock (10)	262

In the U.S.A. the mortality statistics of infants under one year (exclusive of still-births) in the city and rural registration areas are as numbered :—

		Cities.	Rural Parts.
1900	111,687	87,334	24,353
1901	97,477	77,008	20,469
1902	98,575	78,997	19,578
1903	96,857	77,643	19,214
1904	102,880	82,530	20,350
1905	105,553	83,826	21,727
1906	133,105	93,376	39,729
1907	131,110	92,940	38,170
1908	136,432	92,314	44,118
1909	140,057	91,005	49,052
1910	154,373	100,191	54,182
1911	149,322	91,712	57,530
1912	147,455	91,516	55,939
1913	159,435	94,454	64,981
1914	155,075	92,139	62,936

The year 1915 is the first year when the birth-rate is given for the States, and then only from a population of 31,000,000, or about 31 per cent. of the total. For that portion of the American people the infant mortality per 1000 births (exclusive of still-births) worked out as: Cities, 103; New York, 99; Rural, 94.

In brief, thickly-peopled industrial and mining districts usually show a higher rate of infant mortality than do rural areas. This higher rate is not, however, confined to infants, but also to other years. Thus in the rural districts of Scotland (1913) the death-rate was 13 per 1000 of the estimated population, but over 17 per 1000 in the larger boroughs; some of the smaller boroughs displayed an even higher rate—instance, Port-Glasgow, a crowded river port, with 22 per 1000. Taking the figure 13 as against 17, we perceive how the denser the folk the tendency to a higher rate of death among them.

Of the 1,100,000 babies added to the population of England, Scotland, and Wales in the year 1905, not more than a round 820,000 reached five years of age: 290,000 souls dropped into the great urn. The figures are round, but what odds among so many?

This takes no account of the mortality of children before birth, the conditions of mother and child before birth, or the question of the limitation of the birth-rate, conscious and unconscious.

In infants the vulnerable points are the lungs and the guts, and

the directly administrative difficulty is to shorten and clean the tube from the living udder of the cow to the lips of the child.

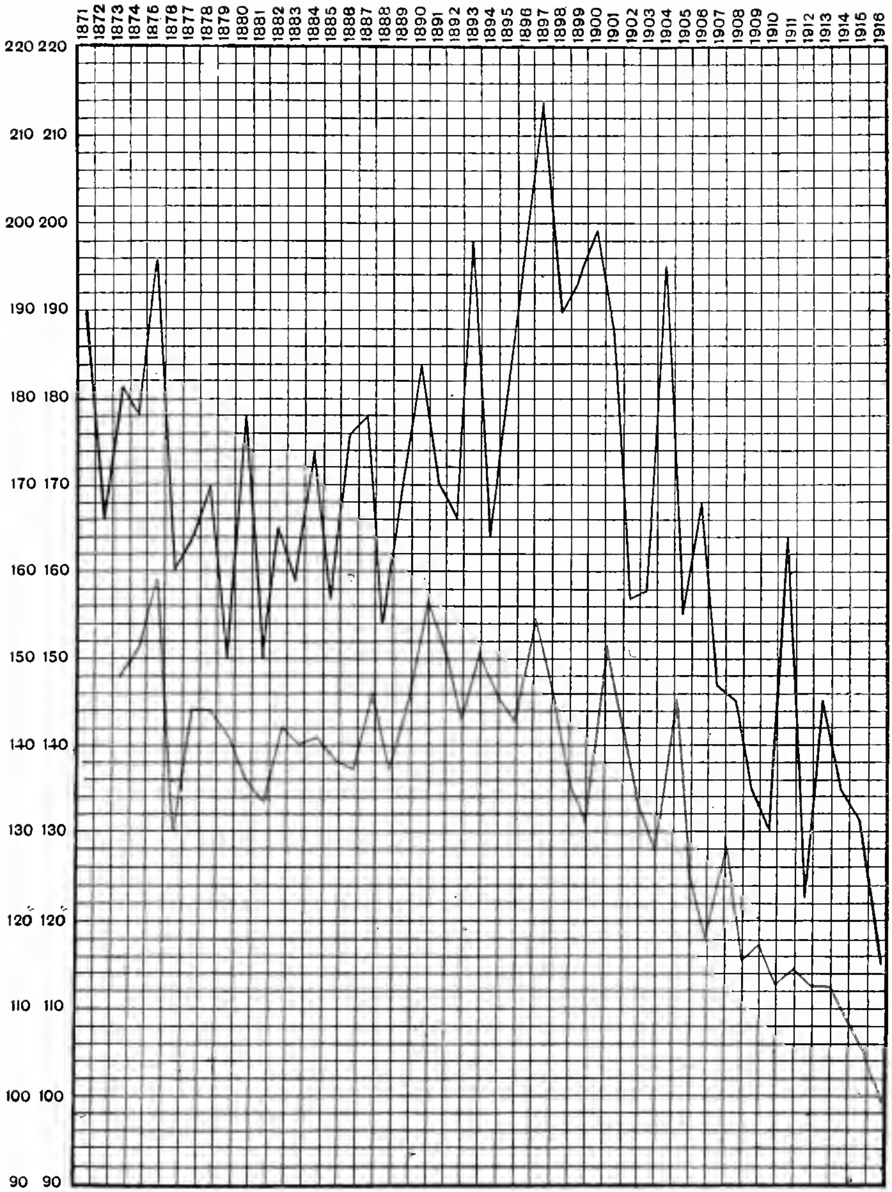
That the death-rate is one of handling and social circumstance, not one of inheritance, does appear in this: newly-born children, even of the poorest mothers, weigh well at birth; in Glasgow, over 7 pounds.

And concerning the subsequent childhood mortality, from one year to five years, after the first year has been overcome, Dr John Robertson writes in the 1916 Report of the Medical Officer of Health for the City of Birmingham:—

> "The total deaths of children between one and five years of age numbered 1275 in 1916, giving a death-rate of 16·1. Much can be done to limit this mortality and avert bad health by timely advice.
>
> "These children are not usually those born in a weakly condition; often they are the most robust, and, having escaped the danger of the first year, may be regarded as sound lives. It is, therefore, very important that their mothers should know how to prevent death when many of the so-called simple ailments of childhood overtake them.
>
> "This mortality is clearly due to ignorance, and is preventable. It does not take place among the middle and better classes, where there is not so much ignorance. Measles, whooping-cough, diphtheria, bronchitis, and pneumonia and diarrhœa should not cause death if care is taken early enough and continuously.
>
> "Then it is found that during these early years the commencement of many ailments are met with which lead to inefficiency in later years, *e.g.* rickets, carious teeth, spinal adenoids, rheumatic conditions."

An incidental result of the European War of 1914–1918 was a survey of the health of the people. It was done haphazard and on no simple plan, and mistakes were sometimes made. But one salient fact emerged, the bad condition of the teeth of our community. Figures are not available, but it is a conservative estimate that one man in every ten was put out of action by defective teeth.

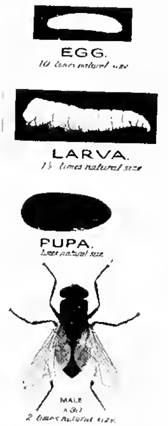
The reason of this is not absolutely certain. It would be interesting to find whether town and country children are equal sufferers in this respect. One large building was watched in one of our cities, and within a year from building the stone façades and cornices



(*By Dr John Robertson.*)

FIG. 273.—Infant mortality of the City of Birmingham, 1871–1916.

were eaten away as if by disease. A similar change has been noticed in the vicinity of gasworks. It may be due to the acids of coal and sulphur gas blown from houses and works and factories into the



(By the permission of Dr J. H. Ashworth of the University of Edinburgh.)

FIG. 274.—One cause of infant mortality.

Growth of the common house-fly; egg—larva—pupa—fly. 14–20 days from egg to fly in warm weather.

(After J. H. Ashworth.)

FIG. 275.---House-fly ejecting the contents of its stomach.

atmosphere, since upon the Pentland Hills the drifted snow, once pure, lies soiled by the reek of Edinburgh.

We can reasonably argue that if even stone be affected by this corrosion, the more delicate bodies of children will not readily escape its influence.

On page 259 is an interesting diagram made by Dr John Robertson,

Medical Officer of Health for the City of Birmingham, illustrating the infant mortality there per 1000 births from 1871 to 1916 :—

The top line—from all causes.

The second line—from all causes less diarrhœa and inflammation of the gut.

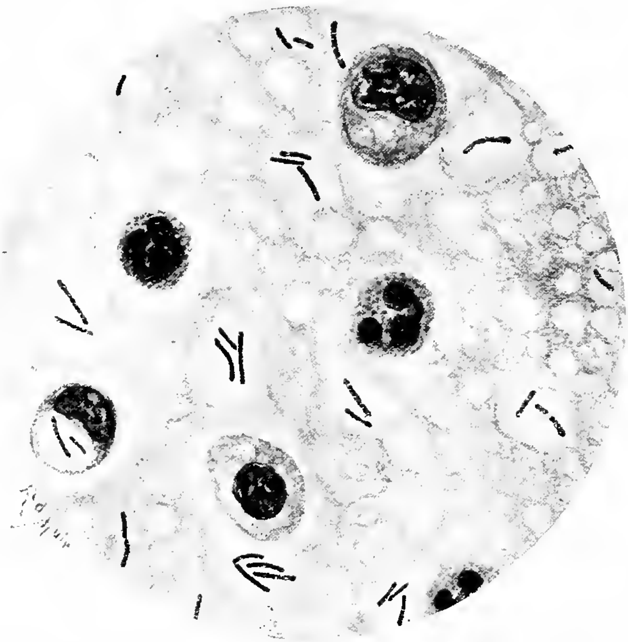
It serves to indicate the improvement which has taken place in recent years. Yet it would be a mistake to remain satisfied with this general improvement: Birmingham is well laid out compared with some cities. Thus the *Report of the Royal Commission on the Housing in Scotland* (Cd. 8731) states that in 1911 over 62 per cent. of the total population of Glasgow were living in houses of one or two rooms, compared with 36·7 per cent. in Edinburgh, 63·1 per cent. in Dundee, 38·6 per cent. in Aberdeen, and 47·9 per cent. in all Scotland, as against 7·1 per cent. in England. In Glasgow no less than 291,224 individuals (or 38·6 per cent.) were living more than three in a room. And it is not easy to see how a virtuous populace can be weaned and reared in such conditions!

Problems of Space.

To resume. At first sight it would seem too sudden to pass from the subject of infant mortality to one of the most fiercely contentious questions of the day. But there exists a close relation between disease and surroundings. And there is little sense in discussing and dissipating into the problem of education before we have dealt with land and houses, if only in a general way. For where is the use in teaching a child if you forbid it first air ?

In the city of Belfast in the year 1916 no less than 830 out of 6496 who died were killed by consumption ; but these figures, though striking, give no real indication of the ravages of the tubercle bacillus. Go to the outdoor department of any hospital for the young, and observe how frequently children are riddled more or less, in gland and lung and bone and joint, by that consuming pest. This tubercle bacillus hates the light, avoiding it whenever it can. It prefers close quarters, dark dwellings, low and congesting roofs. It lurks in dust. It is breathed in by all of us. It is not infrequently present in milk. Mr A. P. Mitchell of Edinburgh in the years 1911–1913 obtained 406 samples of mixed milk to be drunk by the children of Edinburgh, collected from 406 milkshops, and found 82 samples (or 20 per cent.) contained tubercle bacilli.

You have a right to thrust a child into a crowded class-room to breathe spoiled air only if you take it from a well-ventilated dwelling. Modern ventilation of schools has improved greatly. Yet this achievement need not blind us to the fact that a sound body is the surest basis of a sound mind. And a sound body is not attainable without the four dimensions of the child—space and light, and



(*Drawn by Richard Muir, Edinburgh.*)

FIG. 276.—Tubercle bacilli from dairy milk, greatly magnified. For the organisms of human consumption compare also Plate III.

air and water. Hence the problem of houses and the ground on which they stand precedes the problem of training.

The chief obstruction to an understanding of land and house is its complexity. This complexity is at once a safeguard and a danger: a safeguard, because it prevents hasty interference by persons ignorant of the subject; a danger, because the slowness of social betterment consequent on the intrinsic difficulties of the subject tend to lead to grave disturbances among the people affected, for the worse a man's surroundings the more discontented and extreme he is prone to become.

Let us begin by professing ourselves entirely ignorant of the question, which is the only hopeful springboard from which to take the plunge. What does the difficulty involve a knowledge of ?

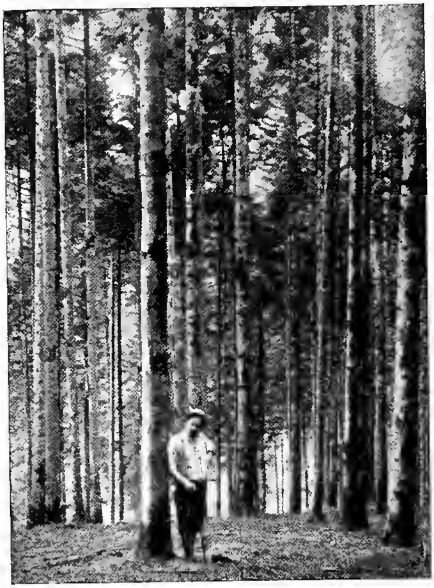
Firstly, the problem entails a naked-eye acquaintance with the land, both in country and town. In which connection the more one knows about practical agriculture the better ; and this is not easy, for agriculture is a skilled trade.

Secondly, the problem calls for a grasp of the system of land

Fig. 277.—Young trees, the Thuringian Forest, Germany.

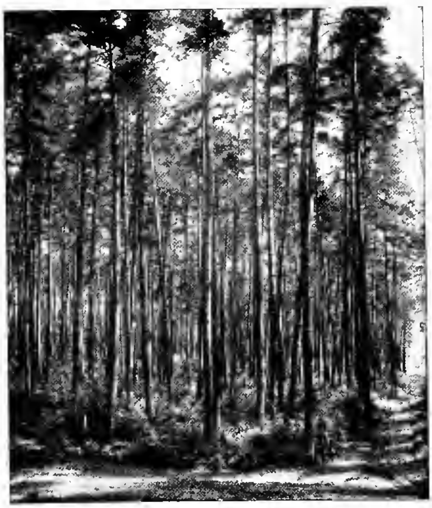
tenure, taxation, and rating, at home and abroad. Which again demands a passable acquaintance with the laws relating to the holding and exchange of land. Scotland, for instance, has its own needs and laws distinct from those of other nations.

Thirdly, the problem involves consideration of the course of improvement, already made in the health of the body public, by the administration of corporate and municipal bodies. To offer but one instance, Forestry : it would include an understanding of the difficulties faced in such a forestry survey as that conducted by Lovat, Stirling, and Nisbet over the Caledonian Canal area in Glen Mor ; it entails some appreciation of the close relation between smallholdings, woods, and water transit ; the uses of wood in industry



(*Photo by Mr J. Lyford-Pike, Edinburgh.*)

Fig. 278.—Silver firs in the Black Forest near Freiburg.



(*Photo by Mr J. Lyford-Pike, Edinburgh.*)

Fig. 279.—Scotch pines in a German forest.
Note how the ground is already planted with a second crop of trees.
Observe also the size of the man.

(*Photo by Mr J. Lyford-Pike, Edinburgh.*)

Fig. 280.—Valley in the Spessart, Germany.

Showing a typical view in a country where poor land has been brought to yield a valuable harvest.

(*Photo by T. J. Walls, Edinburgh.*)

Fig. 281.—A scene showing similar land in Scotland under a policy of neglect. Highland glen by Loch Tay.

and chemistry; and it involves an honest comparison of Scottish with Continental forests—how, as these authorities aver:—

> "With a total area of 7,000,000 acres the Prussian State forests yielded in 1904 over 412,000,000 cubic feet of wood, equal to a fall of about 65 cubic feet per acre actually stocked; and of this more than one-half was used as timber, and nearly one-half as fuel. The gross income was over £5,854,400, *the expenditure* £2,755,230 (*or averaging* 7s. 10½d. *per acre*), and the net income £3,099,170, showing a net revenue of 9s. 7d. per acre actually culturable. During the year 32,000 acres were naturally regenerated, sown, or planted at a cost of £43,500; and *employment was given to* 156,772 *hands for a total of* 10,479,589 *days*" (*Afforestation in Scotland*, p. 77).

FIG. 282.—A typical Scottish forest. Comparatively few stems to the acre.

We have to beat that record by the provision of a Scottish Ministry of Trees and Bairns.

The Parliamentary Sub-Committee upon Forestry appointed in July 1916 estimate that there are not less than three, and probably more than five, million acres of land utilised for rough grazing, but capable of growing first-class timber. Of this area 2,000,000 acres could be put under timber without decreasing the home production of meat by more than 0·7 per cent., and it would ultimately give employment to at least ten times the number of men now employed by grazing.

Fourthly, it involves understanding of a stuffy room; of the nature of the gases and organic matter we expire from our air passages and lungs, and the results of breathing these gases and organic matter upon the bodies of adults and, especially, of the young.

Fifthly, the problem supposes an intelligent appreciation of the subject of town-planning.

Sixthly, it involves some business understanding of the ways and means of building houses, their architecture, their cost; including the cost of the raw materials of building, stones, bricks, cement, wood, and wages.

Seventhly, it means a realisation of the distinction between the value of a house and the value of the land bared of the house; a distinc-

FIG. 283.—Henry George.

tion first clearly enunciated by the work of the American investigator Henry George (1839–1897), who pointed out that man is a land animal. He verifies the earlier French economists, contrasts the advance of science (coal, steam, electric power, machinery, telephone, telegraph, post, ship) with the slower advance in general welfare, and advocates the transferring of governmental taxes from houses and other helpful improvements by the individual to the bare land. As this value of bare land is the work of the community, he considers it a fit subject for bearing rates and taxes :—

> "As land is necessary to the exertion of labour in the production of wealth, to command the land which is necessary to labour is to command all the fruits of labour save enough to enable the labourer to exist."

Eighthly, we have to pay attention to the best methods of freeing our great cities from congestion and excessive centralisation. Transit by air in large numbers is a speculation ; transit by surface is possible by car and rail,—but the first is slow, the second often circuitous ; transit under ground remains, but is undeveloped. No doubt city congestions can be solved by the construction of electric undergrounds, radiating from the centre like the spokes of a wheel, or like the foraging

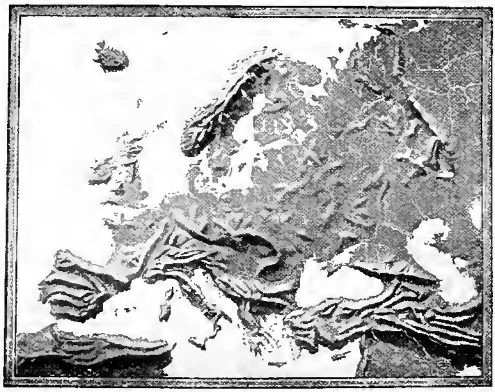


Fig. 284.—Europe.

roads which spread out from an ant-hill. But no municipal body can venture the expense of other than pottering schemes without return. And unless the central municipality is entrusted to rate a share of the increasing taxation-value of the suburbs it creates, the communal effort will be indefinitely suspended and postponed.

Ninthly, the problem of land is to be considered in relation to the internationalisation of the land of Europe; for the internationalisation of land, together with the internationalisation of law, proceeds only by way of each nation freeing its own.

Now, these several branches of the aforesaid subject cannot well be mastered by one man, and the problem of land and housing would thus appear at first sight beyond solution. Without goodwill it is absolutely so. Yet though one man does not walk seven ways at once, seven men may ; though faggots yield when broken one by

one, they hold firm in a bundle. "Monsieur," said d'Artagnan, "you must confess that association is a wonderful thing." "How so?" replied the stranger, with his mouth full. "Well, I will tell you," replied d'Artagnan. The stranger gave a short truce to the movement of his jaws in order to hear the better. "In the first place," continued d'Artagnan, "instead of one candle, which each of us had, we have two." "That is true!" said the stranger, struck with the extreme justness of the observation.

(*After Arthur Lyon Bowley, "Elements of Statistics."*)

FIGS. 285 and 286.—Weekly wage expenditure.

A. At 4d. per hour. B. At 8d. per hour.

The horizontal scale represents pence per hour. The vertical scale represents number of hours per week. The areas represent amount spent. The whole rectangles show the week's wages.

And the splitting of the big estates into small holdings, with the growing of forests on disused or partially used ground, the extension of road and rail and canal, the supply of reasonable and—ultimately—elegant dwellings in the place of tenemental slums, the cheapening of the loaf, the freeing from intoxication, a closer social co-operation in industry, and the rearing of a hardy and alert race of boys and girls, depend on the union and purposeful co-operation of the workers of the people, the immediate aim being breathing space, leisure, emancipation from the bare struggle to exist. Poverty, dirt, drink, vice can only

be crowded out; which process in the British Isles will be quickened, amplified, varied and enriched by administrative and legislative extension, from London to Edinburgh, Cardiff and Dublin.

And with it all we should remember the human factor, the inertia to surroundings. Folk get used to anything. City children sent to the country by the Fresh Air Fortnight Fund when asked if they like the fresh air, often say they would like to be back where they came from. Or again, a workman and his wife were travelling on the top of a car through one of the pleasantest suburbs of one of our most congested cities. The husband said, "This is very quiet," and the wife replied, the distaste ringing through her voice, "It's terrible!" She actually entertained aversion to open quarters.

Our eyes often roll but slowly in their sockets. Take Scotland, for instance. Its climate in summer is fair and invigorating, in winter it is—unique! Often raining, foggy, sleety, cold, it is not for the delicate. Robert Louis Stevenson sentenced the weather as "a downright meteorological purgatory in the spring."

In the months of winter we miss the sun, which struggles to reach us from the south; there is a farm in Glen Lochy, by Tayside, lying to the southern hillside, on which the sun never lights for six weeks every winter. And despite a four to six months of hospital treatment the consumptives in the city of Glasgow, though they had been discharged as "arrested or improved," persist in dying; even the milder cases sent to the sanatoria connected with the city do the same. A man was being examined by the X-rays in the outdoor department of one of our great hospitals; he had just returned from a sanatorium, and felt ever so much better; but the X-rays disclosed the dark spots of tubercle still in his lung. He turned to go. A friend of the writer followed him out. "You think yourself improved?" he asked. "I do indeed," said the man. "You are not! Return to this sooty atmosphere, where you contracted your trouble, and you die." "What shall I do, then?" asked the man. "Book a passage to Canada on the first boat. Get out of here!" The advice was brutal, but a week after the man returned with his ticket booked.

But it is not every one who can afford this step, emigration. And in view of the fact that a man harbouring the bacilli of tubercle is a danger not only to himself but also, by infection, to others, corporate management is natural and essential.

Let us assume for a moment (1) the presence of a cross-Channel tunnel, bringing (2) the ever-warm, ever-green, and ever-bright Swiss valleys to our very threshold, (3) a Scottish Parliamentary Government,

and (4) a Scottish Ministry of Health. What, then, is to prevent (3) through (4) renting a part of a Swiss valley (2) and establishing

(*After Rollier of Leysin.*)

Fig. 287.—Disease *versus* Sunlight.

Scene in a valley of the Swiss Alps. Boys haymaking on a station some 3000 feet above sea-level.

a thorough fresh-air and sun treatment for the tubercle-ridden youngsters of Scotland. Have not, indeed, many of our landsmen made their way across to the continent—even without a tunnel ? It is

(*After Rollier.*)

Fig. 288.—Naked to Nature.

but a day off. It is in damp and mist and rawness that the children contracted the affection—in humidity ; let it be in the opposite of these that they recover. Pour the farm-milk and cream into them till their sores heal and they wax fat and kick with exuberance.

They say there is no money! What say they? Let them say! No money? Well, even if it were so, is it not cheaper to right them at once and early than have them festering on for years and spitting broadcast over others and in every tram-car? Is it not preferable

(*After Rollier.*)

FIGS. 289 and 290.—Consumption in a boy.

(1) On arrival at the Swiss station. (2) After a year's interval. Mark the bronzing of the skin.

to rent a sanatorium in a climate available for twelve months than in one where the "season" lasts but for six?

The sun is the freer, the spinning earth is the holder. And they wrestle and tug for the bodies of man and animal and plant.

If you cannot rent a few farms, then rent a whole valley.

Yes, of course there are difficulties! But difficulties! difficulties! They were sent us to be surmounted.

Could we but grasp the open and extended hand of Nature, how happy we should be!

TRAINING

" Be inspired with the belief that life is not a mean and grovelling thing to be shuffled through as we can, but an elevated and lofty destiny."—W. E. Gladstone.

" The power of thinking, even if it can be acquired to a modest degree, is a much greater possession than feats of memory."—W. Macewen.

" Because our aim is to discipline for activity, for work, for good ; not for immobility, not for passivity, not for obedience."—Maria Montessori.

" ' How do you know that God is beautiful ? ' Willie of the Canongate replied, ' Because He keeps Hissel' clean.' "—Lileen Hardy.

" The great pull which ordinary useful work has over all spurious imitations, however well camouflaged, is the human interest engendered. The difference is the same as that between the work of a haymaker in glorious sunshine and that of a soldier doing kit-drill in dismal barracks, both physical exercises, but the one interesting and soul inspiring, the other drudgery."—Robert Wallace.

" ' I see,' said Stalky, ' I shoved my hand there.' "—Rudyard Kipling.

" It is in the study of everyday facts that all the great discoveries of the future lie."—John Perry.

The traveller slowly descended the hill, glancing from side to side. And as he went he espied before him, set upon a certain eminence, a dome. A flight of steps led up towards its pillars. He made for them, mounted them and entered, for it was the heat of the day. Within was cool and lofty, and as his heel struck upon the marble floor, the sound whispered far into the stillness and returned to him again. He laid him down upon a bench, and dozed and dreamed of his home and wife and children. He muttered words, and of a sudden it seemed as though the voice and spirit of the organ began to heave and murmur and beat and tremble in answer, the air all round him became pregnant with tone and laden with meaning, and an echo sounded from the massy walls to the vaulted roof and back, to touch his ear. It came lightly like incense. He knew not whence it came.

" I intend to educate them well," he said.

Music.—Education is a word. It has lost its early freshness. Derived from the Latin *duco,* " I lead," and *e,* " out," it conveys the picture of a teacher extracting certain qualities from the child, as you dig cheese out of a round.

Echo.—You regard that as an assumption ?

Music.—A grievous one, for no one knows what the actual qualities of a child are. Let us employ the term as sparingly as may be.

Echo.—But, first, have you any especial right or knowledge, my

unseen friend, to embark on such a shifting ocean as this attempt implies ?

Music.—None, beyond the judgment of the average man or woman.

Echo.—But what, then, are the credentials of this man for whom we play ? First tell me, what is his interest in training ?

Music.—Two children, a boy and a girl, that is all. Where shall we begin ?

Echo.—Why, at the beginning.

Music.—That is in the anatomy room.

Echo.—How that ? You will hardly find a trainer there !

Fig. 291.—Charles Bell, Scottish surgeon.

Music.—In this way. Charles Bell was born in 1774 and lived till 1842, a good round age. He was the Scottish anatomist who pointed out in his *New Idea of the Anatomy of the Brain*, published in 1811, the distinction between the sensory and the motor nerves. Would you like to hear how he managed to do so ?

Echo.—I make no objection !

Music.—Each nerve joined to the spine along two routes, a front and a back. So Charles Bell took a rabbit, cut the front route of a nerve, seized the cut end towards the limb with a forceps, and the muscles of the limb twitched and jerked. Again he cut the back route of a nerve, seized the cut end towards the limb with a forceps, and the limb did not move at all.

Echo.—What did he infer from that ?

Music.—That the motor strands to a limb ran *out* by the front route, and the feeling strands from the limb ran *in* by the back route.

Echo.—Like enough. I walk forwards and not backwards.

Music.—Thus Charles Bell distinguished motor strands from feeling strands. He relates of another experiment : "On cutting across the nerve of the fifth pair on the side of the face of an ass it was found that the sensibility of the parts to which it was distributed was entirely destroyed. On cutting across the nerve of the seventh pair on the side of the face of an ass, the sensibility was not in the slightest degree diminished."

Echo.—And what did he deduce from this ?

Music.—Why, that the fifth nerve pair are nerves of feeling, and that the seventh pair are nerves of motion.

Echo.—And what was the good of it all ? Has a man any right to torture animals in this fashion ?

Music.—Bell did not like it either, and used experiment only as a last resource. And he proved that in the nerves, spine, and brain there were special strands which sent the feelings of the skin to the centres within, and special strands bore the pulses of motion out to the muscles. Some nerves contain only sensory strands, others only motor strands ; he, therefore, distinguished these nerves as sensory and motor respectively. Some nerves contain both sensory and motor strands. The different nerves and tracts and columns of the brainy substance he found " devoted to distinct offices."

Echo.—But what has this to do with education ?

Music.—With training ? This much ; that as the brain of your child works by way both of feeling and of doing, you should train it to climb along both these branches.

Echo.—That is an artificial distinction.

Music.—It may prove a natural one.

Echo.—I see your intention. You mean his children should exercise not merely their memories but also their muscles. But they do that already in the playground and gymnasium and training corps. They cannot carry the jersey and flannels into the schoolroom.

Music.—Exactly what they should do. Better a jersey round their bodies than a towel about their heads. Your modern education is lopsided ; it aims at teaching to remember, it stops short of training to think, and, what is more, to act.

Echo.—But there is no time. You keep a boy or girl at school till fourteen. They learn little enough of the facts of past experience as it is. Assuming the alphabet, spelling, singing, reading, writing, drawing, arithmetic, and English grammar, they are introduced to geography, history, English literature, a modern language, an ancient language, religion, and geometry. Surely to peace these are sufficient without training them to think !

Music.—You have mentioned several subjects. Permit me to arrange them upon the facts, sensory and motor. A child hears the alphabet spoken, or rather, he hears the sounds of vowels and consonants, and he watches the teacher's lips. He is using his ear sense and his eye sense. Is he not feeling ?

Echo.—He is indeed.

Music.—And in grammar is he not being instructed through his ears and eyes ? And in learning pieces of English poems and dramas and novels and speeches ? And in acquiring the facts of geography and history, the French language, and the Latin or Greek verbs, or in memorising chapters of the Bible, or in conning the elements of mathematics, is he not still ever receiving at the porches of his ears and eyes ? He is drawing in as a sponge draws in water. Is he not ?

Echo.—Yes, that is so.

Music.—But when his child draws his pencil over paper, or forms his simple lines and curves into the shape of letters, or traces the outline of the coast of a map, or adds up a sum, or in declaiming on his feet some eloquent passage, or in vaulting, swinging, and turning in the gymnasium, is he not putting out exertion, doing something ?

Echo.—I agree.

Music.—So, then, the subjects of training you mention, along with a number of others you do not mention, fall into two groups :—

Sensory.

1. The *alphabet* and *spelling*.
2. The blackboard and the picture film.
3. *Grammar.*
4. Memorising of *English*.
5. *History* and *Geography*.
6. *Religion.*
7. *French* and modern languages.
8. *Latin, Greek.*
9. *The facts of numbers, geometry, and mathematics.*

Motor.

1. Breathing, speaking, declaiming' *singing*, debating, play-acting.
2. Observing.
3. Tracing, *drawing, writing*, painting, dictation and word painting, essaying.
4. Knitting and crocheting.
5. Pottery, typewriting, the piano, violin, violoncello, and flute.
6. *Counting, geometry*, equations and other mathematics.
7. Timing.
8. Swimming, walking, marching, running, gymnasium and physical exercises, dancing, jiujitsu, boxing, fives, fencing, football, cricket, golf, tennis, badminton, rounders, baseball, bowling, curling, rowing, steering, sailing, riding, cycling, photography, scouting, archery.

I note the subjects you mentioned, which, you observe, fall mainly on the sensory side. Your sensory subjects outnumber and outbalance your motor subjects, you perceive ?

Echo.—That is correct.

Music.—So the child of this man is being trained more hours of the day to feel than to do ?

Echo.—It looks like it.

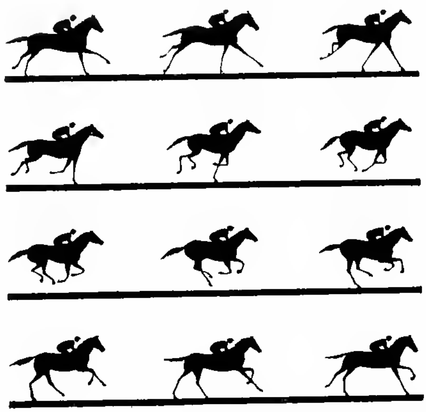
Music.—The mind of the child is being influenced in the direction of feeling rather than acting ?

Echo.—So it appears, if your tenor be sound.

Music.—His training is ill-balanced therefore ?

Echo.—Ill-balanced ? I was not aware of it.

Music.—And the more earnest and dutiful the child, the more ill-balanced he will tend to become ? Put it this way. Which do you prefer, that this man's boy or girl would know or would do ?



(*The Illustrated London News.*)

FIG. 292.—Timing. Instantaneous photographs of a galloping horse.

Echo.—Both, for they cannot effect until they acquire. A baby starts by seeing and listening, and a child by imitating.

Music.—Yes ; but in his lifework which would you prefer, that he should know facts or act deeds ?

Echo.—The latter.

Music.—That is, his training should be harmonised to the end that he became a captain of difficulties, a planer of knots ?

Echo.—No doubt.

Music.—Then his motor faculties should be exercised at least as many hours in the day as his sensory parts. And you admit that does not obtain in the subjects you mention ?

Echo.—I said so.

Music.—So his child is being warped to the degree his subjects are more sensory than motor ?

Echo.—That is not his wish, and indeed he has often felt, as does also his wife, that the children's lessons, their memorising, take them over-long at nights.

Music.—Lessons ? What are they ?

Echo.—Exercises in memory for the next day.

Music.—But he has already exercised the memory of his child during his day at school ?

Echo.—Yes, but he does the same again in the evening.

Music.—He does ? At what hour, then, does his eldest leave for the school in the morning ?

Echo.—At nine o'clock.

Music.—And when does he return ?

Echo.—At half-past four.

Music.—Is he in the air all that time ?

Echo.—He is at school.

Music.—Out of doors ?

Echo.—Part of the time ; mostly within doors.

Music.—But in the evening he is free to play before going to sleep ?

Echo.—Yes ; but in the evening he learns his lessons for the next day.

Music.—You repeat yourself. What are these lessons of which you speak ?

Echo.—In preparation for examinations.

Music.—Examinations ? What next ? But what *are* these lessons you speak of ?

Echo.—Reading and spelling and poetry and such things.

Music.—He does these things ?

Echo.—No ; I told you he learnt them.

Music.—Now, do not become loud and angry. You say he learns ? How long in the evenings does he learn ?

Echo.—Oh, for an hour and a half or so.

Music.—He adds yet another hour and a half to the sensory side of his son's training. Is that well balanced ?

Echo.—It is not.

Music.—The scale falls to the heavier side. And both sides should be weighted equally.

Echo.—Yes ; and to meet that he provides for the physique of the children both in the gymnasium at school and in such schemes as the Boy Scouts and the Girl Guides. They afford a fuller training.

Music.—Cannot he himself afford that ?

Echo.—Yes ; but the mottoes of these unions are : Be Prepared ! They train the boy and the girl to act.

Music.—You agree, then, that the early training of the boy and girl should be a harmony of feeling and doing ?

Echo.—Yes.

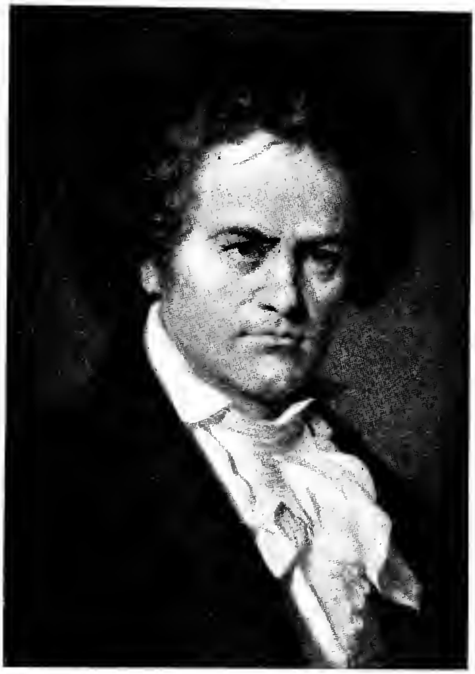


FIG. 293.—Beethoven.

Music.—That is, before ever he thinks of any particular employment or lifework ?

Echo.—Yes.

Music.—But what next shall we call his later training, in his teens, in his apprenticeship for building, or cabinet-making, or plumbing, or painting, or engineering, or typewriting, or clerking, or accounting, or teaching, or healing, or administering, or ploughing ; shall we call that his career ?

Echo.—No ; his career is the actual performance of his work and the earning of his livelihood. The word you are seeking is, his aim.

Music.—Good ! So training falls into the phases :—

(1) Harmony, or general training.
(2) Aim, or bread-winning training.

Echo.—That seems clear enough.

Music.—And you deem harmony should precede aim ?

Echo.—Indeed yes, for you must train to fourteen before you train to twenty-one.

Music.—So harmony takes precedence of aim ?

Echo.—Surely, surely.

Music.—For the pupil is most readily influenced when young ?

Echo.—Yes.

Music.—So the teacher of his child up to the age of nine or ten should be trained better and paid better than he who guides his child from ten to sixteen ?

Echo.—I am not so sure of that ?

Music.—But at least you agree that harmony deserves close attention ?

Echo.—Yes, I admit that.

Music.—What, then, is the first sense ?

Echo.—Sight.

Music.—It is vision !

The traveller opened his eyes and stared with a startled air. Yet the great slabs lay still with the sun beaming on them, and the pipes of the organ towered high into the dimness of the roof. " Strange," he muttered, " I thought I heard a sound." He turned on his side and dozed again.

Music.—How many senses are there ?

Echo.—Five.

Music.—Seven.

Echo.—No !

Music.—Yes ! Apart from vision, there are sight, hearing, touch, weight, taste, smell, and breath. Which are the most important of these ?

Echo.—Sight and hearing.

Music.—Some perceive by the eyes, others best by the ear. But on the whole the eye is the greatest help, especially along with touch.

Echo.—Yes, I would prefer to be deaf than to be blind.

Music.—For with it depends the use of touch and form and weight.

Echo.—Touch I think I understand. But form ? and weight ? what of them ?

Music.—I place a golf-ball in your hands. Feel it.

Echo.—It is round. It is covered with little prominences.

Music.—You distinguish the prominences by your sense of touch. You distinguish the bigness and shape and form of the ball also by your sense of touch.

Echo.—That is touch, but what is weight ?

Music.—There is your handkerchief ; spread it over your right hand. There is a stone ; take it in your left, and place it upon the handkerchief in the hollow of your palm. Now poise the stone up

(*Photo by Margaret Pirie, Edinburgh.*)

Fig. 294.—First attempts to represent shape and form by a child of 3¾ years.

The white discs are cut from paper to the size of the balls, shown once ; sight memory. The black balls are clay modelled to the form of the balls, felt once ; feel memory.

and down upon your handkerchief and palm, testing its thrust towards the ground. Close your eyes. Do you feel that ?

Echo.—Yes.

Music.—Do you feel this now ? Is there a difference in the feel ?

Echo.—Yes ; it feels to me as if it were a small pebble.

Music.—You appreciate the difference ?

Echo.—Yes. The second was lighter.

Music.—Was it the sense of touch ?

Echo.—No, for neither the stone nor the pebble touched my hand.

Music.—It was the sense of weight.

Echo.—Humph !

Music.—But enough of that. Which comes first, the act or the word ?

Echo.—Explain yourself.

Music.—That is your concern. You speak of long and short,

tall and small, thick and thin, broad and narrow, deep and shallow, hot and cold, heavy and light, old and young, fast and slow, black and white. These you call opposites.

Echo.—Yes.

Music.—Does his child recognise them as such ?

Echo.—He does not know.

Music.—Why does he not know ? What is the age of his youngest?

Echo.—Three and a half years.

Music.—Set a heavy thing and a light thing upon its hand with its eyes shut, and he will find—ah ! he does not know what he will find. But there was once a child of that age, and a block of alum having split into a big piece and a heavy piece, they were set in turn upon her hand, her eyes being shut. She poised these up and down, and obviously she felt the difference between them, but she called the lighter one " heavy," the heavier one " not heavy." She knew the difference, but she knew not the words.

Echo.—She understood, but could not express herself. She knew not the proper words for her experience.

Music.—The act precedes the word ! Further, the idea of contrast and difference a child understands, but the idea of opposite, as in heavy opposed to light, is not so plain to him, it is more artificial. For one can grasp a distinction without implying an opposition.

Echo.—Yes, I agree.

Music.—By the way, has he trained his children ?

Echo.—He has sent them to school.

Music.—Why ?

Echo.—It is the rule to do so.

Music.—The rule ? Whose rule ? His rule ?

Echo.—Yes, I suppose so. Every Britisher goes to school.

Music.—What to do ? Is it to observe the points ; to seize out the essentials ; before acting to consider the results ; but once determined, to proceed swiftly, steadily, and without fear.

Echo.—Not so. They go to learn to read and write and count. They instruct their children in a great many schools. They give them lessons to drill their memories. They bring to the front the talents the child inherits, and prepare him for his trade or profession to which nature and his station have destined him.

Music.—Station ? Station ? That is a word difficult to understand.

Echo.—Well, you see, if his qualities are limited, then he must be a labourer ; if they are manual, they make of him an artisan ; if he

is not keen on money, surrender him for a teacher; if he be of an agile wit and fairly honest, they send him to business; if he inherits ability and cash, he goes to law, medicine, or politics; if he is better than the rough and tumble, they make of him a minister.

Music.—They regard the child as a passive sponge. Go on.

Echo.—As his special training earns him food and happiness, they start it as early as possible, instilling and dovetailing in the necessary details, so that he may not fail in the line he has to follow. They give their citizens a working grip of their subjects. They are proud of them.

Music.—I perceive their state falls into two expert divisions: first, the officials; second, the workers.

Echo.—Yes, their trend is towards a government by ability.

Music.—They believe in interference?

Echo.—Yes, for good.

Music.—Who is the judge of that?

Echo.—The able man, of course.

Music.—But here is one thing I do not grasp. How do they tell when one child is able and when one is stupid?

Echo.—If his parents are ready to spend money on his advancement, then he is probably able.

Music.—And what happens to those whose parents die, leaving them without money?

Echo.—They fight and shoulder their way.

Music.—Always?

Echo.—Usually.

Music.—You speak of "their way." What is the way? Is it an early way or a late way? Many lads early accounted dunces blossom out afterwards when they reach their work. One of their leading island scientists, William Ramsay, confessed that he never did much good at school. And some boys are naturally backward; Young and Fresnel were pioneers in the early nineteenth century, but while Young read at two years, Fresnel did not read till eight years. Ludwig Beethoven, the master of harmonious sound, was slow in unfolding to the full. Both Julius Cæsar and Oliver Cromwell started their lifework after they were forty. Do they in their schools try to stimulate to a free and self-mastering activity those children and youths who gather their strength but slowly?

Echo.—The whole fleet cannot wait on the slowest ship.

Music.—Then the slowest ship is dropped. If training is not to the quickening of the slow, if it bring not interest, freedom,

spontaneity, independence, decision, activity, attention, earnestness, will, enterprise, adventure, joy, broadcast, what reward does it carry ? Harmony is the play of the mind. Anything which strains to excess the body or the mind is bad. Shall you seek to break the will of the child ?

Echo.—Nay ! rather let it will to be one.

Music.—Respect thine own judgment.

Echo.—But say, how can these things come ?

Music.—Slowly but surely. And not by the passive machine they call education. A working knowledge is gained only by doing the work. Let us devote our strength not to instructing or leading out certain presupposed qualities, but to stimulating the child to exert and make a new hand and mind and carve a new path for himself and for others. For this, is school atmosphere—religious, academic, or commercial—to be advised ?

Echo.—I do not know.

Music.—Believe me, they are not. Dogma throttles intelligence. The worst stupidity is an educated stupidity. A son wants to be so trained that in after business life he will never make a mistake without being able to proffer a sound reason for it. Memory is a first action every time, never exactly identical to the last time. The brain is active. Therefore in your harmony lay stress not so much on memory work as on the direct action of light and sound and touch and weight upon the senses. The lad will not be expected to perform the impossible and learn at second hand, but through what he sees with his own eyes, hears with his own ears, feels with his own fingers, and does with his own hands. Through his own work. Do you agree ?

Echo.—Thoroughly, and in consonance with your tone.

Music.—Shall you start with the simple and single or with the difficult and complex ?

Echo.—With the simple.

Music.—With single colours—black, white, red, yellow, green, blue, violet ? With flowers and plants ? With simple tuning-forks and gongs and bells, or with single notes of the harp and the piano ? With simple shapes, round and flat, circles and triangles and squares, and cubes and pyramids and crystals, rough and smooth ? Their length and breadth and height and tug to and fro ? With weights equal and different ?

Echo.—Yes.

Music.—Then you will begin to associate and combine the several senses ?

Echo.—How so ?

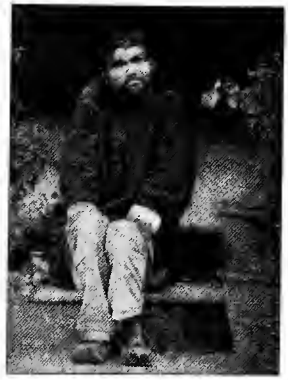
Music.—The brain starves by starvation, it grows by growing. Here is a picture of the wolf-man Sanichar, an Indian lost while a baby among the wolves. He cannot speak. Because he was surrounded by wolves. You can read it in his face. His brain was starved.

Echo.—Yes, he might be sweeter looking.

Music.—The less blindness and deafness, the more sight and hearing. Further, which do you remember the better and easier, a passage if heard once and read over, or a passage heard twice (or read twice) ?

Echo.—I suppose the passage which is both heard and seen.

Music.—" It is the senses," said John Locke, " that furnish the yet empty cabinet." The greater the number of avenues, the lighter the forest. And the senses can be associated with profit, the eye with the touch, and so on. To appreciate the value of the hand, hear the words of the woman who was born blind and deaf and dumb :—



(From a negative lent by E. P. Culverwell of the University of Dublin.)

FIG. 295.—Sanichar, the wolf-man.

" I have just touched my dog. He was rolling on the grass with pleasure in every muscle and limb. I wanted to catch a picture of him in my fingers, and I touched him as lightly as I would cobwebs ; but, lo ! his fat body revolved, stiffened and solidified into an upright position, and his tongue gave my hand a lick. He pressed close to me as if he were fain to crowd himself into my hand. He loved it with his tail, with his paw, with his tongue. If he could speak, I believe he would say with me that paradise is attained by touch ; for in touch is all love and intelligence. . . .

" My hand is to me what your hearing and sight together are to you. In large measure we travel the same highways, read the same books, speak the same language, yet our experiences are different. All my comings and goings turn on the hand as on a pivot. It is the hand that binds me to the world of men and women. The hand is my feeler, with which I reach through isolation and darkness and seize every pleasure,

every activity that my fingers encounter. With the dropping of a little word from another's hand into mine, a slight flutter of the fingers, began the intelligence, the joy, the fulness of life. Like Job, I feel as if a hand had made me, fashioned me together round about and moulded my very soul. . . .

"The delicate tremble of a butterfly's wings in my hand, the soft petals of violets curling in the cool folds of their leaves or lifting sweetly out of the meadow-grass, the clear, firm outline of face and limb, the smooth arch of a horse's neck and the velvety touch of his nose—all these, and a thousand resulting combinations, which take shape in my mind, constitute my world. . . .

"The thousand soft voices of the earth have truly found their way to me—the small rustle in tufts of grass, the silky swish of leaves, the buzz of insects, the hum of bees in blossoms I have plucked, the flutter of a bird's wings after his bath, and the slender rippling vibration of water running over pebbles. Once having been felt, these loved voices rustle, buzz, hum, flutter, and ripple in my thoughts for ever, an undying part of happy memories. . . .

"If a fairy bade me choose between the sense of sight and that of touch, I would not part with the warm endearing contact of human hands or the wealth of form, the nobility and fullness that press in to my palms."

Echo.—But how can this woman hear sounds when she is deaf ?

Music.—By vibration. She says, "With my own hands I have felt all these sounds." And not otherwise for the child ; sounds, words, pass from one ear to the other, unless he paws them. Show him your watch and explain it to him ; it is a lesson ; he strains to follow you, and forgets again. Show him a sand-glass for egg-boiling and explain it ; it is a lesson ; he strains to follow you, and forgets again. But show him them both together, and ask him to ascertain whether the sand-glass records a minute at the same moment as does the second hand of your watch. It is a game ! He compares, his mind begins to work, he shouts in glee, he remembers and comes back to "play it again." He has made a thought for himself. Remember that selfishness is the usual precursor of self-sacrifice.

Echo.—Oh, the children are keen enough on games, but life is not all a game.

Music.—Let it remain so as long as possible; keep them from specialising early. Tell me, how would you teach the alphabet?

Echo.—I would show him the letters and tell him, this is A, and this is B, and this is C. How else?

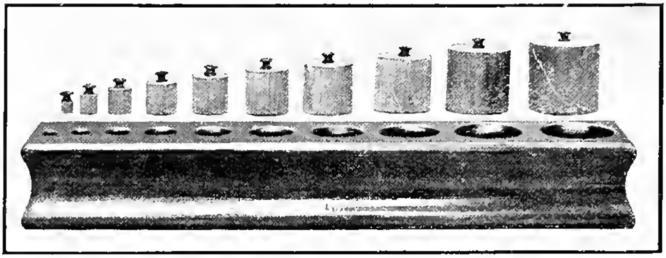
Music.—A, B, K, you mean. Anything more? No? Surely!

(*From a photo in the possession of E. P. Culverwell of University of Dublin.*)

Fig. 296.—Maria Montessori, the children's trainer.

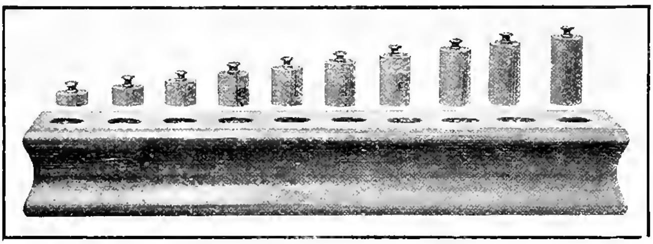
Give him a new game, a piece of sand-paper and a pair of scissors, and let him cut out the letters for himself and paste them on a cardboard with your help. Then let him shut his eyes and feel the shape of the rough surface of the letter A and the others, and race the next boy at distinguishing the one from the other. He has now the triple grip, eye and ear and touch. And you avail him of both his sensory and his motor pulses. Then let him shape the letters out of clay.

And in learning to write, you will plot for the child a circle and a triangle, and tell him to fill in the inside spaces with a pencil.



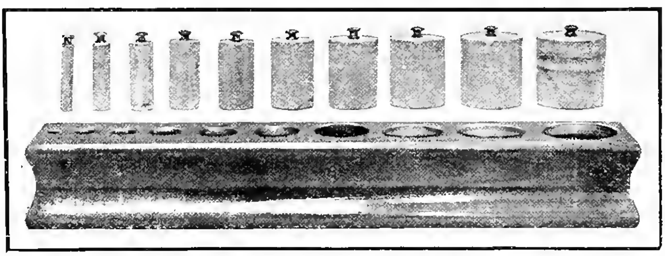
(*After Maria Montessori. This and the ensuing by Philip & Tacey, London.*)

FIG. 297.—Cylinders of varying diameters.



(*After Maria Montessori.*)

FIG. 298.—Cylinders of varying depths.



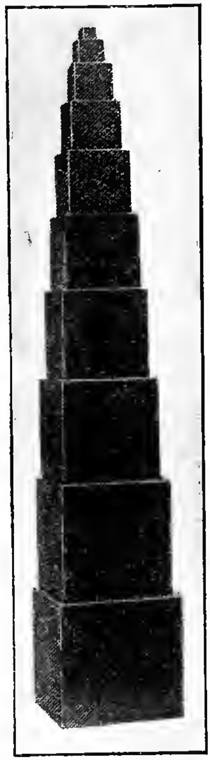
(*After Maria Montessori.*)

FIG. 299.—Cylinders of varying diameter and depth.

Echo.—He will make many mistakes and overstep the edge.

Music.—Naturally, but each time he does it better, making his lines more and more parallel and straight. And later, in writing the names of the world's lands you will furnish him an atlas, to combine

the motor and sensory memories. You will also invite him to model the atlas in clay. You remember the picture—the child Handel discovered at midnight playing the piano, on his own initiative. The child selects as well as sees. Arouse the curiosity present in every sensible creature. Stimulate it, and you will find that the greater the range of sensory feelings, the greater the range of motor choice, and the truer the activity of the child. Do you recommend that they introduce limelight into the schools ?



(After Maria Montessori.)

FIG. 300.—The tower.

Echo.—The cinema ?

Music.—Perhaps not often, it strains the eyes. But limelight slides ?

Echo.—If it is feasible.

Music.—Everything true is feasible. Let them use their own eyes. Then invite them by questions to reason from their own observations. An ounce of thought outweighs a ton of facts. Smother not the instincts in ink. It is the simple, the obvious, that teaches best.

Echo.—What then ?

Music.—Let us turn back to our double list of subjects, sensory and motor. And let us regard them without prejudice to the efforts already made by so many splendid men and women. We speak of breathing, speaking, declaiming, singing, debating, play-acting. For the child begins by breathing, but as he grows he speaks more and more distinctly, then he repeats simple pieces of poetry and prose, he sings, he discusses—however simply—with his companions, and as he questions and answers he brings the muscles of his face and arms and body into play. So every child is an actor. But if he is to act and speak, is it well that he speak better or worse ?

Echo.—Better and more distinctly.

Music.—His trainer, then, should be trained in the art of choice elocution and clear speaking, and should have free access to the best plays of ancient and modern times.

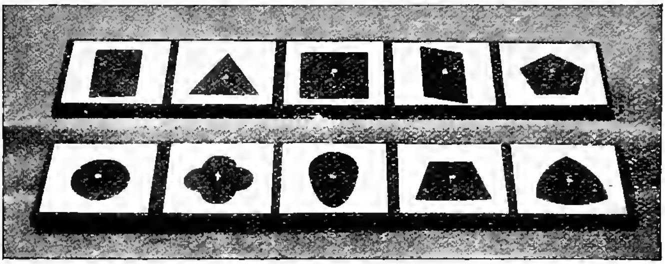
Echo.—Yes.

Music.—There should, then, be a national theatre in association with the schooling and the picture-house ?

Echo.—Yes, and space provided either in the school or separately for such school theatres.

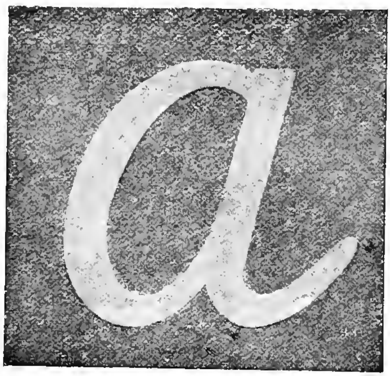
Music.—And the children should be able to perform simple plays among themselves.

Echo.—They should.



(*After Montessori's Handbook.*)

Fig. 301.—Metal insets and frames, of various shapes.



(*After Montessori's Handbook.*)

Fig. 302.—Sand-paper letter.

Music.—And you trust the actors and actresses of England and Scotland and Ireland and Wales to assist to that end ?

Echo.—I do, indeed.

Music.—Then, secondly, there is observing. We placed that among the motor subjects ?

Echo.—We did, because we move the eyes from one direction to another.

Music.—But we feel the light through our eyes ?

Echo.—Yes.

Music.—The babe feels first the impulse of light and then moves his eyes towards the window, so that observing is a subject both sensory and motor.

Echo.—It is.

Music.—And the child will remember better and more easily

(*After Maria Montessori.*)

Fig. 303.—Sound boxes.

(*Photo by W. A. Mansell.*)

Fig. 304.—Assyrian bas-relief, in the British Museum.

according as observing becomes sensory and motor at the same time.

Echo.—What mean you ?

Music.—We spoke of memory being sensory. Is that right ?

Echo.—It seemed so.

Music.—It is not ; it is also motor. Give a child a billiard-ball

and a golf-ball, and tell him to draw their size on paper. Then measure them with the compass. The memory of that is sensory.

Echo.—Yes, for the shape of the balls travels from the balls to the eyes.

Music.—But blindfold him and let him feel and paw the two balls. Then let him take a pencil and trace the shape of the balls on paper. The memory of that is motor.

Echo.—Why so? It depends on the touch of the fingers as well as on the play of the muscles of the forearm.

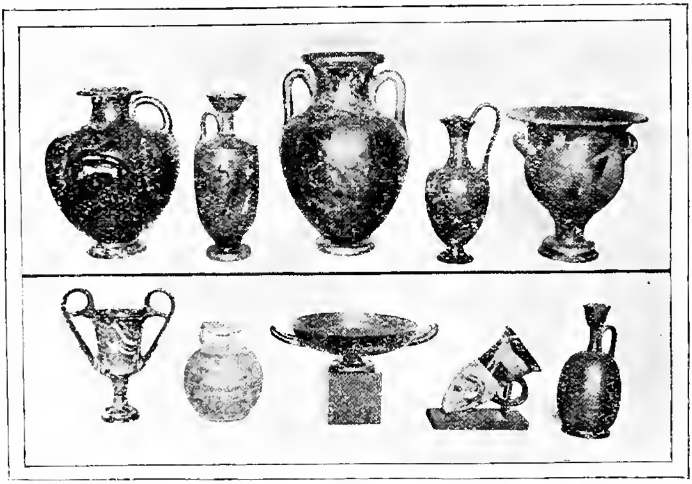


FIG. 305.—Types of ancient Grecian vases, in the Louvre, Paris.

Music.—Perhaps you are right in that objection.

Echo.—And for that matter, if the remembering from blindfold depends on the moving of the forearm muscles, the remembering of seeing depends on the moving of the muscles of the eyeball.

Music.—Perhaps so.

Echo.—So it appears that sensation and motion are so united as to run the one into the other, to be sometimes practically indistinguishable. So your distinction is useless between sensory and motor, is it not?

Music.—No, the distinction is useful; it has enabled you to point out a fault in my reasoning. And if you reject it, can you proffer me any better distinction in terms?

Echo.—Not at the moment.

FIG. 306.—The Theseus, from the Parthenon, Athens, time of Phidias. Now in the British Museum.

FIG. 307.—The Aphrodite of Melos.

Music.—Let us hold to it, then. Knitting, for instance, illustrates motor memory to us, does it not ?

Echo.—It does indeed.

Music.—And the sending of Morse signals by means of flags, is it not ?

Echo.—It is.

Music.—Which is easier to do than to read signals ?

Fig. 308.—The head of the Hermes: by Praxiteles.

Echo.—I believe so.

Music.—Well, that's motor memory. Then in observing, the child should receive a number of objects to feast its eyes upon and to move its eyes from one to another ?

Echo.—Yes.

Music.—And it is well that his trainer should help him in that ?

Echo.—It is well.

Music.—But to direct the pupil of the pupil successfully it is well that the trainer should himself have seen ?

Echo.—I agree therewith.

Music.—But if the trainer is to see, his eye should be previously accustomed to seeing objects ?

Echo.—That would seem reasonable—many objects and qualities.

Music.—Such as the form of the body, its working, and especially the working of the delicately and firmly poised brain and nerves, and further, the objects of nature, in plants and animals, and in the elements and bodies of the earth ? For of all professions, the trainer's is the most refined.

Echo.—Yes.

Music.—A working knowledge of the main facts of what we call anatomy, physiology, psychology, botany, zoology, physics, chemistry, and geology, are these essential ?

Echo.—They are indispensable and inter-related.

Music.—Some slight knowledge of the stars might prove of value, after he has handled the earth. And these are but the implements of the trainer's profession.

Echo.—As the tools are to the gardener.

Music.—But the trainer is to understand also the main lines of the commerce he resides in and feeds off ; and for that he requires at least a general grasp of the past history of his native land, as expressed in action and in letters, and to some degree the history of other lands. Which again supposes and involves a geographical understanding of various countries, a vision of the globe itself and all that we inherit ; their customs, their language, their literature, their exports and imports, their struggles for spiritual emancipation. And this may even take him as far back as the Egyptian, the Hebrew, the Greek, and the Roman.

Fig. 309.—Niobe and her youngest daughter : school of Scopas.

Echo.—It may.

Music.—And to these ends, if he has to pass any examinations of fitness at all, it should be on the subject of such general knowledge, and if he passes with success he should receive a certificate for general improvement.

Echo.—Yes, for he will then have proven these natural objects into himself.

Music.—But without sympathy these things are useless. Which

Fig. 310.—The Laocoön.

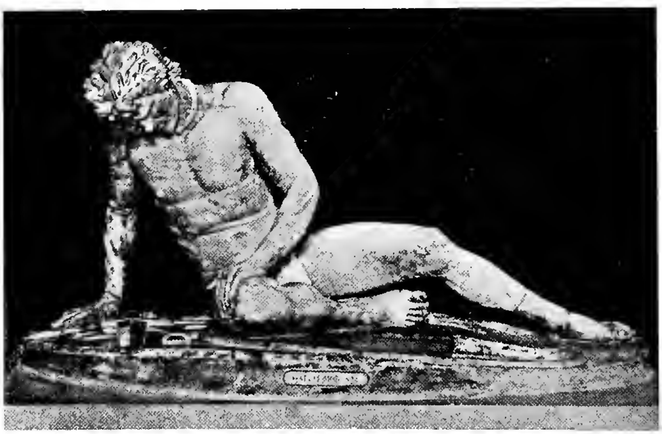


Fig. 311.—Dying Gaul: the Coliseum, Rome.

prefer you for the children of this man, to aid them and gather their attention, a teacher of facts or a bearer of sympathy ?

Echo.—The latter.

Music.—Yet of two with an equal sympathy, you would prefer the one with the fuller training in observing ?

Echo.—I would. But what of sympathy ?

Music.—That deeper yearning of the heart, as in the heart of

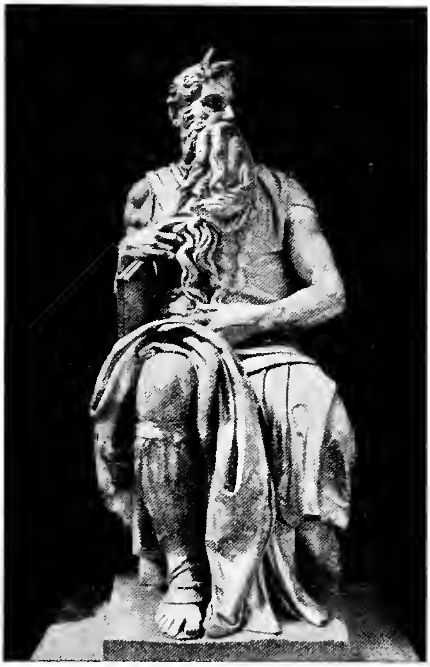


Fig. 312.—The Moses: by Michelangelo.

Jesus Christ of Nazareth, when he cast His eye down from the Mount of Olivet over the city of the Jews and felt towards it :—

> " Ah, Jerusalem, Jerusalem, thou that killest the prophets, and stonest them which are sent unto thee, how often would I have gathered thy children together, even as a hen gathereth her chickens under her wings, and ye would not ! "

The drone of the great organ melted away. The traveller stretched his limbs, yawned heavily, and turned on the other side. The air filled once more into the stillness.

Music.—Have we time to take up each subject in turn ?

Echo.—We have not.

Music.—Yet counting is of consequence, for it, too, is both a learning and a doing, and a useful training for the child.

Echo.—What of it, pray ?

Music.—Shall our counting be easy or difficult for the child ?

Echo.—Easy, for the more time he saves at one branch, the further he will travel in that and in other branches.

Music.—With what do you count ?

Echo.—With numbers.

Music.—Every system or symbol of numbers—English, Morse, decimal, septimal—is artificial. Each is a language of numbers, as French, German, Spanish, Italian, English, Esperanto are forms of speech, and both words and numbers are hand-movements. We may write the name or word of the Western Isle in sixteen finger movements either as BRITAIN, or in the signalling and telegraphic code, as — · · · · — · · · — · — · · — · We may write the numbers one, two, three, four either as 1, 2, 3, 4, or as · — — · · · — · — · — · · And since these are artificial ways and means, we need not hesitate to discard them whenever a simpler one presents itself. Whether the decimal system will itself yield to some more natural count, measure, and weighing is open, but that it is simpler than the system at present in vogue in that Western Isle is certain.

FIG. 313.—Lorenzo de Medici: by Michelangelo.

Echo.—What mean you by the decimal system ?

Music.—The reckoning in tens.

Echo.—I have heard it mentioned for the coinage.

Music.—In coinage it would run after this manner :—

1 copper is roughly 1 farthing.
2 coppers make 1 cent.
4 coppers make 1 penny.
10 coppers make 1 nickel.
25 coppers make 1 silver.
50 coppers make 1 shilling.
100 coppers make 1 florin.
250 coppers make 1 alum.
500 coppers make 1 gold.
1000 coppers make 1 pound.

Echo.—Reducing the number of coins to ten.

Music.—Reducing the confusion. Here is a random sum for adding :—

£	s.	d.
28	15	$9\frac{1}{2}$
37	7	$11\frac{3}{4}$
11	19	$6\frac{3}{4}$
4	1	$5\frac{1}{4}$
6	17	$10\frac{1}{4}$

Seven separate lines have to be added and three separate divisions to be made, the first by 4, the second by 12, and the third by 20. The sum is—

£89, 2s. $7\frac{1}{2}$d., or eighty-nine pounds, two shillings, and sevenpence halfpenny.

Echo.—And on the decimal coinage ?

Music.—It would be—

£28/790
37/399
11/976
4/072
6/893

Totalling £89/130 or eighty-nine pounds, one florin, and three nickels.

Five lines to be added, and no division to be made.

Echo.—That would be a saving of time, a relief of worry, and a release of activity, to the young !

Music.—The simple is aye the best. Life is more than an obstacle race. And some day yet the franc, the mark, the shilling, and the dollar may accelerate to an amalgamation.

Echo.—But you mention another subject, timing.

Music.—A most important one, but over-long to consider now. Time is a very precious metal. How much is a man's span ?

Echo.—Seventy years.

Music.—How long are these years ?

Echo.—Seventy—only seventy.

Music.—Are they not eternity, back and front ?

Echo.—Now, now, what mean you ?

Music.—Again, we spake of physical exercise. Shall a trainer be a man or a woman, physically fit ?

Echo.—Undoubtedly.

Music.—If, then, he is to be examined, shall he not be asked to run a distance of a hundred paces ?

Echo.—Surely, and be a swimmer, and photographer, and boxer, and be acquainted with the vulnerable points of the body, in health and disease. Indeed he might specialise in one such physical hobby, such as Swedish training, so as to train the youth therein ; and be examined thereon, if indeed an examination be a good thing.

Fig. 314.—Mother and child: by Michelangelo.

Music.—Then shall he learn and teach to shoot ?

Echo.—Certainly.

Music.—What with ?

Echo.—With a rifle.

Music.—What is a rifle ?

Echo.—A metal machine to project a bullet.

Music.—Towards what ?

Echo.—Towards a grouse or rabbit or man.

Music.—Wherefore ?

Echo.—So that they may die.

Music.—But we seek to train the youth, do we not ?

Echo.—We do.

Music.—Then shall we train the youth to project a bullet at a man, so that he may die ?

Echo.—Yes ! No ! I cannot say. It appears scarcely the act of a gentleman. Yet a rifle trains the eye and steadies the hand.

Music.—What of the bow ? Does it too train the eye ?

Echo.—I suppose so. It aims at a target with a feathered arrow. The archers of England were once the finest in the world, men of firm and unbreakable spirit.

Music.—Does it train the fingers and the arm and the steady balance of the body ?

Echo.—Yes ; in the stringing of the bow and the drawing of the

arrow to the head, the bending and spanning of the bow and the aiming at the mark.

Music.—Is it equal to the rifle in these respects ?

Echo.—Yes.

Music.—And is it advantageous in respect that the entire action is performed by the boy even to the flight of the arrow ?

Echo.—The rifle is quite automatic in projecting the bullet.

Music.—The bow is, therefore, the superior of the rifle in point of training ?

Echo.—So it would appear.

Music.—And it affords a means or instrument on which the boy may set a care and pride in the keeping of it dry and well stringed in a case. Does it not also give a means of competition between classes and teams ?

Echo.—Yes ; but that demands space to its proper exercise.

Music.—Even in the densest cities there are public parks. And is the space required more than in the shooting with a rifle ?

Echo.—No ; less open space is wanted for the bow than for the rifle, for its range is less.

Music.—And the boy could not possibly imagine the shooting of an arrow is to train him for the killing of life, could he, now ?

Echo.—No, he could hardly imagine that.

Music.—Then tell me, why is the bow not more used than it is ? Is it more expensive to make than the rifle ?

Echo.—No, the bow is cheaper. One can buy twenty bows of various strengths and sizes for the price of one rifle.

Music.—It is puzzling that there is not yet a profitable industry for the making of these instruments, for the demand for them would be greater than for tennis-racquets and cricket-bats, would it not ?

Echo.—It is strange indeed. But tell me of the teacher : in what things besides archery shall he stimulate the youth ? Inform me of a few of the facts of practical observation.

Music.—The touch of bodies, their shape, their length and breadth, and height and thickness and edges, their feel, their weight, their form, their colour, and texture and graining ; the sea, earth, and tides ; why the water ebbs and flows twice a day ; the moon, the sun, the planets, of the fall of a stone to earth ; the properties of water, steam, ice ; of all that we inherit ; concerning the action of moisture, frost, winds, and forests ; of gases ; of oils ; mercury, the thermometer and the barometer ; the graining of rocks and crystals ; of iron, lead, tin, aluminium, copper, silica, and their uses in commerce ; the pendulum ;

the effects of mechanical strain ; the nature of the strains of light, heat, phosphorescence, sound, and the telephone and its parts ; the electric cell and circuit and the magnet ; telegraph and wireless ; the discovery and working of the phonograph ; the spinning-top ;

Fig. 315.—The archer of Sans-Souci.

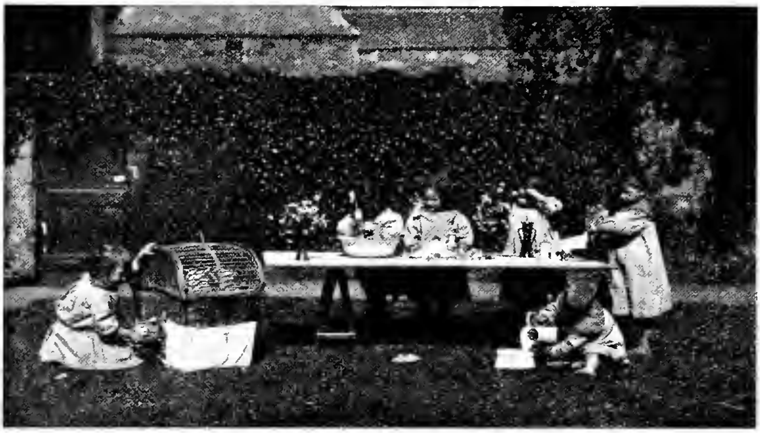
the gyroscope, the telescope, the microscope ; of grasses and flowers, and roots and leaves, and trees and crops ; of bulbs and their growing ; of the potato; of animals and their handling and habits ; the aquarium ; of coal, its raising and its applications to dyes ; of soap, boots, clothes, paper, mechanical models, motor cars, locomotives and dynamos, bridges, yachts, ships ; clay modelling, pottery and vase-

making ; the plaiting of baskets and mats, the uses of the bamboo ; of the building, sewage, lighting, airing, furnishing and garnishing of houses ; of woollens, cottons, linens, silks, embroidery, pictures and sculpture ; of the making of bread and butter ; of the action of yeast ; of muscle and its action ; of the making and effects of alcohol ; of tea, sugar, milk, cream, and good cooking ; simple facts of blood, circulation, respiration, and digestion. For the boy to brush his teeth properly ; to breathe through his nose, and to expand and harden himself with exercise ; to keep his temper even in a quarrel ; to try to be strong enough to regard the body of a woman and his own honour as one. For the girl to see that her blood is kept pure and unmixed ; to darn her stockings ; to inform her of the possible objections to the bowels acting only once in ten days ; to cook a meal, to bake a loaf, and to train her both for the regular sleep-and-feed management of children and for the exercise of a political judgment co-equal with that of her future husband ; of resuscitation from drowning, and some knowledge of first-aid to the bleeding, the burned, or the fractured ; of bones and joints and muscles ; some faint notion of the movements of trade and business energy and public purpose visible around us ; of labour and barter and trade ; how man came to employ fire, and steam, and electric power ; the growth of weaving, pottery, sculpture, painting, printing, lithography, and the arts. The elements of courtesy. Actuality ! Not teaching from the real to the ideal, or from the ideal to the real, but discovery of the ideal in the real. To project the mind is bad ; to focus it is good, and the gain of one is the gain of all. And scores of similar points of naked-eye inquiry, for the children to work out with their own eyes and hands. How to do old things. How to seek new things. " What have you seen to-day ? What have you done to-day ? " These are one or two points.

Echo.—But enough for a start. Some of them are being done already.

Music.—So that the boy or girl of this man will not leave their school an educated cattle, dangerously ignorant of their own bodies and the facts of everyday existence. They will not be over-drilled in past memory work, it is true ; but they will come to think independently, and without always having someone jogging and explaining and correcting at their elbow. Less avizandum, less interference. Men and women who will maintain an independent honesty of purpose, dependable to put their whole strength into their work.

Echo.—And incidentally to command higher wages. I should say the more interest to the boy, the higher interest to his employer.



(*After Lileen Hardy.*)

Fig. 316.—Tending plants and animals in the Canongate, Edinburgh.

(*After Lileen Hardy.*)

Fig. 317.—The afternoon sleep.

For alert sight might beget attention, and repeated attention begets the power of concentration. You mention the boy and the girl together; do you then regard them as equal?

Music.—In general: the sounder the society, the higher the respect

and reverence towards woman. In particular: these quotations are here culled from the book of measurements of men and women:—

1. "The sexes are equally variable in respect to brain-weight" (Raymond Pearl, vol. iv. p. 82).
2. "There is no sensible relative difference between the brain-weight for man and woman, when proper allowance is made for the relative difference in size for man and woman" (Blakeman, Lee, and Pearson, vol. iv. p. 160).
3. "There is no significant difference between the two sexes in variability" (J. F. Tocher, vol. v. p. 349).

Comment is superfluous.

Echo.—Is that correct?

Music.—You had better pursue the inquiry yourself if you are in any doubt.

Echo.—To all this there is an insurmountable objection.

Music.—Yes? what, pray?

Echo.—The trainer. To secure a full faculty of observing and a capacity for properly and thoroughly stimulating the child he would require to be not merely a ladler out of facts, but a man of insight, specially trained in naked-eye work, and dealing with a class of moderate dimensions. To be this he is not merely to be well paid for all his early outlay, but raised altogether in social esteem.

Music.—But is he not already in a social order above the politician, the business chief, or the professional man?

Echo.—Certainly not! The average salaries of certificated trainers in the annual grant schools of Scotland in 1912–13 were:—

Masters (Principal)	£189	13	4
,, (Assistant)	138	0	6
Averaging . . .	161	9	9
Mistresses (Principal)	96	0	10
,, (Assistant)	82	5	10
Averaging . . .	83	16	11

The majority of certificated male trainers, nearly half of them principals, received between £100 and £150 a year in salary.

The majority of certificated lady trainers, quite a few of them principals, received between £75 and £100 a year in salary.

That is, a fully trained trainer drew £3 a week or less, a trained mistress 32 shillings a week in salary.

Music.—Salaries ? Why call them salaries ? Wages, you mean ! Ah, but wait, perhaps Scotland pays her secondary schools more sufficiently ?

Echo.—

1st Assistant Masters received	£173	after	9	years'	service.
2nd ,, ,, ,,	£141	,,	7	,,	,,
1st Assistant Mistresses ..	£113	,,	8	,,	,,
2nd ,, ,, ,,	£99	,,	6	,,	,,

Music.—The trainer is therefore esteemed by these people of lighter account than a politician.

Echo.—That is evident.

Music.—Yet the politician cares for the bodies and the trainer for the spirit of the ehild !

Echo.—Yet here is the point : no man in his senses will prepare himself keenly for observing for the bare ehance of £3 a week. He could come out quicker as a business man, a lawyer, a doctor, or a farmer.

Music.—You imply that the wages of the trainers should be considerably raised ?

Echo.—Certainly ; more than doubled to achieve your suggestions. And that is unlikely, for this man here and his friends hold the offiee of the trainer in relatively slight esteem.

Music.—Nevertheless what is said, is said. Tell me, had we always eoal and iron, steam and electric lights ?

Echo.—No.

Music.—Then in training the youth you desire to carry him step by step over the same course of diseovery, allowing him himself to re-make the several advances known up to to-day.

Echo.—That would certainly be of help to the youth.

Music.—How, for instance, an electric light has come to burn ?

Echo.—Yes.

Music.—So that if your training is to be worth, it directs attention not to the end facts attained but to the gradual trend, passage, and movement of humane discovery. Which do you regard of the more consequence, the passage or the end, the corridor or the hall ?

Echo.—You cannot reach the one without traversing the other. Therefore I should say, discovery for the child, facts for the apprentice.

Music.—That is to say, harmony and aim. But to succeed in either a teaeher requires a salary, does he not ?

Echo.—Yes.

Music.—For the trainer should be just. He should inquire the reason of disturbance rather than summarily repress it. If one boy accuses another, he is to be invited to bring witnesses and prove his case. The teacher should never interfere, but listen to the trial. The class becomes the jury.

Echo.—Yes, that is useful.

Music.—And the class rules should be determined by the boys and girls themselves. They shall be their own governors and self-silencers. Have you heard of the boy of eight who belonged to such

(*By permission of Thos. Forman & Sons, Nottingham, owners of the copyright and publishers of the large coloured plate.*)

FIG. 318.—Exploration: by J. C. Dollmann.

a self-ruled class, and was asked by his father on his return late one day why the mistress had kept him in ?

Echo.—No.

Music.—He replied, " The mistress did not keep me in ; I kept myself in ! "

Echo.—He knew he had overstepped his own rules.

Music.—If the powers of motor choice are not to be trained and stimulated in youth, if not then, when ? Trained to select from their earliest, they are enabled in after years justly to elect each other to positions of responsibility and influence. We saw the outcome of a manly independence at Salamis and Marathon and Thermopylæ, in the rise of the Roman republic, in the Scots, in the Swiss, in the defence of Leyden, in the colonists of Elizabeth and New England, in the voyagers of Portugal and Holland and Norway, Vasco da Gama and

van Diemen, Nansen and Amundsen, John Cabot and Humphrey Gilbert, Pirie and Scott.

Echo.—Yes, I daresay. The actual exertion of an unfettered choice and individual election is to the realisation of character and an experience of life by the masses of the people. Rely upon it, truer action arises by the conflict of opinions. And any thing or man which deprives or prevents or nullifies or strangles or hampers that unfettered choice and action is a waste of good time and an error. Is this so ?

Music.—Ay, it is so.

The notes died away and the air grew quiet ; when swiftly to the traveller it seemed as though the space of the dome filled once more and became the heart of a pulsing beat ; far away, then nearer, ever nearer. And the music seemed to weave and gather into a regular and yet irregular tread, the sound as of thousands of feet together. And a Voice spake and sang into his very ear, swelling to the last chord and eddying away, like the water on the bosom of a river, like the sand upon the foreshore :

" Do you not hear them ?
The unborn nations !
The march of the peoples ! "

The traveller shook himself, sat up and peered around. All was still. Dusk lay between the pilasters. Stiffly he groped for the entrance. The evening star was bright in heaven. " It's better out here," he breathed in the cool night air. " It was a dream," he said.

ACTIVITY OF BODY.

Into the direct application of the law of life it is not here to enter. It is to be done, not to be shown. Yet it is but right to add a simple illustration of how everyone of us can verify the law for himself.

Take two smooth clean discs of such a metal as aluminium as pure as possible, and, after leaving them some weeks in the dark, take and rub one of them briskly for twenty minutes against a plate *of the same metal* until the disc feels warmish to the skin of the cheek, then place it and the other unrubbed disc side by side on the film of a photographic plate. Leave them now for five minutes in the dark and then develop. The disc that was rubbed leaves a distinct white image of itself. Here we have—

1. Stimulus. Simple friction.
2. Matter agitated to radiate, emanate, or pass out an increase or intensification of its internal activity.
3. Result.—Stronger impression on a photographic plate.

This action comes from the metal, because nothing but the metal was used. The action is neither " heat " nor " electricity," for when an electric action be passed through the disc until it becomes hot to the touch, no image is left upon the plate. It is not " light," for the metals were in the dark six weeks prior to the experiment, and the action proceeds from the *rubbed* disc and not from the control one. It is not " chemical action," for the radiation passes right through to the photographic plate even when the disc and plate are separated by a thin film of black paper. It is not " magnetism," for a magnet does not change the photographic plate in this way.

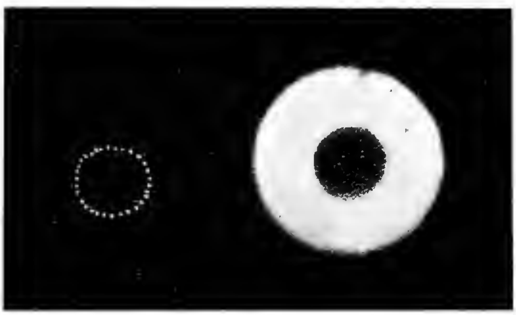
Zinc upon zinc does the same. Bismuth upon bismuth, however, leaves not a white but a black image of itself.

There is no difficulty in verifying this experiment. Anyone can take a penny and, after rubbing it, leave it in a dark room upon a photographic plate.

Now, if anyone desires to call this new quality " activity," ranging it with " heat " and " electricity," he may, but to do that is a mistake. For there is no such separate entity, but simply active matter. A cold disc emits but little activity ; a rubbed disc emits a marked activity. Or, to put it bluntly, the penny is alive. And everything else is the same in this respect.

The world is a live world.

FIG. 319.—Aluminium disc and aluminium plate.



(Photos by S. Fingland, Glasgow.)

FIG. 320.—Two perforated discs of aluminium are laid on a photographic plate in the dark, one unrubbed, the other rubbed on an aluminium plate of the same structure —all in the dark.

The action of the disc is strongly intensified by the friction.

The dotted circle indicates the position where the unrubbed disc was laid on the photographic plate.

FIG. 321.—Action of rubbed disc (in the dark) on photographic plate, penetrating even through a film of black paper.

But there is more in it than life. As we noted, there is an Impulse which pierces; the action from the metal pierces through paper to the plate; or slowly move a magnet towards a needle, and the needle sees it a long way off and suddenly jumps through space to meet it; or the action of light leaps from the sun to the earth. On what do these actions pass? Surely on something!

Stand upon a breakwater and watch the waves as they come rolling in, heaving with a thud against it, and recoiling out once more. Watch that wave! It meets another coming in. They both seem to stop for a second, and then you see it disengage and emerge undaunted, as if nothing had happened. Some action is travelling in the water, though the water itself does not travel, but simply moves

Fig. 322.—Photograph revealing the invisible Body, or Fulness, which we are wont to call "space."

up and down. Let us call it strain; and it is on the body of the water that the strain travels.

Similarly, "space" is in reality Body. To set about proving this is beyond our compass. Suffice to say that this Body has been photographed, and let us now consider one such photograph, of an exceptional clearness. It is a snapshot taken by a No. 1 Guinea Ensignette. It shows a field in France in the process of being pitched with tents and marquees. The shadow of the man in the foreground is cast but slightly to the north, from which we may deduce that the sun is high in the heaven. Some canvas is spread out beside him, and in the immediate foreground the canvas of a marquee is seen thrown up to expose the two upright poles and top cross-pole. But on the photograph being developed something else is observed—a shadowy white image—through which one can look to see the canvas. What is this? Intersecting it are two black lines, and as these lie in line with the two upright poles of the marquee, we may conclude that we have here a reflection or light-reverse of the inner side of the

marquee with the two upright poles. But what is it cast on? It was not visible when the photograph was made, but only after the film was developed. Yet it rests on something. We conclude that between the eye of the camera and the working party there is a substance or body, invisible, impalpable, to the human senses, but visible to the eye of the camera. In other words, the Body in which we live can be photographed.

To go a little further. If activity can be proven at any part of Nature, then the changes of Nature are purposeful, and there exists some Active Drive within it, a Continuous Being or Body struggling for a higher expression.

The whole Body being continuous, each action of each part is felt reverberating throughout the whole, or, in the poetical language of earlier days, not a sparrow falls to the ground unseen, unfelt, unforgotten. And more, even if a single part or individual act in a mistaken way, the action does not end there, is not confined to itself, but agitates the other parts, which in their turn react upon and, in some way yet unknown, compensate for, and thus indirectly control the erring part. On this, man is a free, yet not independent, part of a Body—or, in the words of Christ, we are the sons of a Father.

But, it may be objected, if there be an Active Drive in a continuous substance, then it is responsible for the evil as well as for the good in the world; we are evil, because the Great Evolver is evil; or, to put it another way, there is no evil at all; the ant that kills another, the trout devouring the spawn at the mouth of the burn, the Nero as he murders his mother, being all equally the products of evolution.

The objection is shrewd, but it shatters on the responsibility of man. If the man Nero was active, then, though the aroma of the palace had hung heavy upon him, he was still free to fall. As indeed so is every man of us.

An Active Drive no more precludes the activity of the several parts than a chief of a business is wrong and inept in allowing free latitude to his subordinates to conduct transactions. Hence the liberty of the parts to move, the sudden explosion of a volcano, the falling of a good man by lightning, or the success of an unjust man, affords no necessary argument against an ever-growing purpose in the Universe. The freedom of the part need not be an argument for chance, but against it. And as a straining upwards of freely contending parts can never rest, can never be devoid of pain, suffering and death are no disproofs of an Active Drive. Design expresses itself through struggle, as a child is born by travail. And to the question, Are not

our petty lives but the flutterings of the moth into the candle, the vain and restless breakings of the waves upon the rocks ? there comes reply, To strive upwards is itself the end.

In a word, it is safe for the average man in the street and the young man or woman to believe that Nature is active through and through in every form, from the dull-brown mother-earth to the lark as it sings into the heavens. Man and earth is an animate fountain ; each drop rises, sparkles in the sunlight, curves and falls, only to be reabsorbed in the perpetual motion. The worlds and suns dissolve into smoke, only to reappear in a more ample guise and beauty. But to grasp Activity is beyond us. It is measurable, that is all. Our shallow soundings will never fathom the surging of the Everlasting Deep. God is also within. We shall seek knowledge as little children. The truth of Activity renders it impossible for any scientist, no matter how great and able, to pot the Universe as the cook pots jam ; for before it the reason reels back baffled and the imagination faints. In the words of the Scottish poet, " The heart's aye the part aye, that make us richt or wrang." We may query and never exhaust reply ; the veil obscuring our eyes will never be rent in twain from the very top to the very bottom. We struggle and fall and rise, all borne within the hollow of some Mighty Hand, that strives and suffers and does and moves on. We are ever carried back to the resounding voice of the Hebrew seer :—

> " Canst thou search out the depths of God ?
> Or find the Almighty's limits ?
> The heights of heaven ! What canst thou do ?
> Deeper than hell ! What canst thou know ?
> Longer than Earth the measure,
> And broader than Ocean."

In the flame of Whose Countenance a man dare but trust and pray, Who calls us each by name.

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